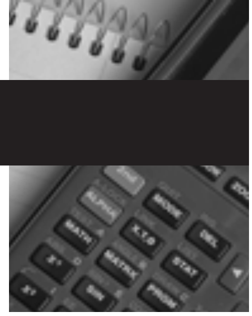

Appendix I Additional Problems

I

The Science of Physics

Givens	*Solutions*
1. depth $= 1.168 \times 10^3$ cm	$\text{depth} = 1.168 \times 10^3 \text{ cm} \times \dfrac{1 \text{ m}}{10^2 \text{ cm}} = \boxed{1.168 \times 10^1 \text{ m} = 11.68 \text{ m}}$
2. area = 1 acre $= 4.0469 \times 10^3$ m^2	$\text{area} = 1 \text{ acre} = 4.0469 \times 10^3 \text{ m}^2 \times \left(\dfrac{1 \text{ km}}{10^3 \text{ m}}\right)^2$ $\text{area} = 4.0469 \times 10^3 \text{ m}^2 \times \dfrac{1 \text{ km}^2}{10^6 \text{ m}^2} = \boxed{4.0469 \times 10^{-3} \text{ km}^2}$
3. Volume $= 6.4 \times 10^4$ cm^3	$\text{volume} = 6.4 \times 10^4 \text{ cm}^3 \times \left(\dfrac{1 \text{ m}}{10^2 \text{ cm}}\right)^3 = 6.4 \times 10^4 \text{ cm}^3 \times \dfrac{1 \text{ m}^3}{10^6 \text{ cm}^3} = \boxed{6.4 \times 10^{-2} \text{ m}^3}$
4. mass $= 6.0 \times 10^3$ kg	$\text{mass} = 6.0 \times 10^3 \text{ kg} \times \dfrac{10^3 \text{ g}}{1 \text{ kg}} \times \dfrac{1 \text{ mg}}{10^{-3} \text{ g}} = \boxed{6.0 \times 10^9 \text{ mg}}$
5. time $= 6.7 \times 10^{-17}$ s	$\text{time} = 6.7 \times 10^{-17} \text{ s} \times \left(\dfrac{10^{12} \text{ ps}}{1 \text{ s}}\right) = \boxed{6.7 \times 10^{-5} \text{ ps}}$

Motion In One Dimension

Givens	*Solutions*
6. $\Delta x = 15.0$ km west $\Delta t = 15.3$ s	$v_{avg} = \dfrac{\Delta x}{\Delta t} = \dfrac{15.0 \text{ km}}{(15.3 \text{ s})\left(\dfrac{1 \text{ h}}{3600 \text{ s}}\right)} = \dfrac{15.0 \text{ km}}{4.25 \times 10^{-3} \text{ h}} = \boxed{3.53 \times 10^3 \text{ km/h west}}$
7. $v = 89.5$ km/h north $v_{avg} = 77.8$ km/h north $\Delta t_{rest} = 22.0$ min	$\Delta x = v_{avg} \Delta t = v(\Delta t - \Delta t_{rest})$ $\Delta t(v_{avg} - v) = -v\Delta t_{rest}$ $\Delta t = \dfrac{v\Delta t_{rest}}{v - v_{avg}} = \dfrac{(89.5 \text{ km/h})(22.0 \text{ min})\left(\dfrac{1 \text{ h}}{60 \text{ min}}\right)}{89.5 \text{ km/h} - 77.8 \text{ km/h}}$ $\Delta t = \boxed{2.80 \text{ h} = 2 \text{ h, } 48 \text{ min}}$
8. $\Delta x = 1220$ km $v_i = 11.1$ km/s $v_f = 11.7$ km/s	$\Delta t = \dfrac{2\Delta x}{v_i + v_f} = \dfrac{(2)(1220 \text{ km})}{11.1 \text{ km/s} + 11.7 \text{ km/s}} = \dfrac{2440 \text{ km}}{22.8 \text{ km/s}} = \boxed{107 \text{ s}}$

Givens	Solutions
9. $v_i = 4.0$ m/s $\Delta t = 18$ s $\Delta x = 135$ m	$v_f = \frac{2\Delta x}{\Delta t} - v_i = \frac{(2)(135\text{ m})}{18\text{ s}} - 4.0\text{ m/s} = 15\text{ m/s} - 4.0\text{ m/s} = \boxed{11\text{ m/s}}$ $v_f = (11\text{ m/s})\left(\frac{3600\text{ s}}{1\text{ h}}\right)\left(\frac{1\text{ km}}{10^3\text{ m}}\right)$ $v_f = \boxed{4.0 \times 10^1\text{ km/h}}$
10. $v_i = 7.0$ km/h $v_f = 34.5$ km/h $\Delta x = 95$ m	$a = \frac{v_f^2 - v_i^2}{2\Delta x} = \frac{[(34.5\text{ km/h})^2 - (7.0\text{ km/h})^2]\left(\frac{1\text{ h}}{3600\text{ s}}\right)^2\left(\frac{10^3\text{ m}}{1\text{ km}}\right)^2}{(2)(95\text{ m})}$ $a = \frac{(1190\text{ km}^2/\text{h}^2 - 49\text{ km}^2/\text{h}^2)\left(\frac{1\text{ h}}{3600\text{ s}}\right)^2\left(\frac{10^3\text{ m}}{1\text{ km}}\right)^2}{190\text{ m}}$ $a = \frac{(1140\text{ km}^2/\text{h}^2)\left(\frac{1\text{ h}}{3600\text{ s}}\right)^2\left(\frac{10^3\text{ m}}{1\text{ km}}\right)^2}{190\text{ m}} = \boxed{0.46\text{ m/s}^2}$
11. $\Delta x = 4.0$ m $\Delta t = 5.0$ min	$v_{avg} = \frac{\Delta x}{\Delta t} = \frac{4.0\text{ m}}{(5.0\text{ min})\left(\frac{1\text{ h}}{60\text{ min}}\right)} = \boxed{48\text{ m/h}}$
12. $\Delta t = 28$ s $a = 0.035$ m/s^2 $v_i = 0.76$ m/s	$v_f = a\Delta t + v_i = (0.035\text{ m/s}^2)(28.0\text{ s}) + 0.76\text{ m/s} = 0.98\text{ m/s} + 0.76\text{ m/s} = \boxed{1.74\text{ m/s}}$
13. $\Delta t_{tot} = 5.10$ s $a = -9.81$ m/s^2 $\Delta x_{tot} = 0$ m	$\Delta t_{tot} = v_i\,\Delta\, t_{tot} + \frac{1}{2}a\Delta t_{tot}{}^2$ Because $\Delta x_{tot} = 0$, $v_i = -\frac{1}{2}a\Delta t_{tot} = -\frac{1}{2}(-9.81\text{ m/s}^2)(5.10\text{ s}) = +25.0\text{ m/s} = \boxed{25.0\text{ m/s upward}}$
14. $a_{avg} = -0.870$ m/s^2 $\Delta t = 3.80$ s	$a_{avg} = \frac{\Delta v_{avg}}{\Delta t}$ $\Delta v_{avg} = a_{avg}\Delta t = (-0.870\text{ m/s}^2)(3.80\text{ s}) = \boxed{-3.31\text{ m/s}}$
15. $\Delta x = 55.0$ m $\Delta t = 1.25$ s $v_f = 43.2$ m/s	$v_i = \frac{2\Delta x}{\Delta t} - v_f = \frac{(2)(55.0\text{ m})}{1.25\text{ s}} - 43.2\text{ m/s} = 88.0\text{ m/s} - 43.2\text{ m/s} = \boxed{44.8\text{ m/s}}$
16. $\Delta x = 12.4$ m upward $\Delta t = 2.0$ s $v_i = 0$ m/s	Because $v_i = 0$ m/s, $a = \frac{2\Delta x}{\Delta t^2} = \frac{(2)(12.4\text{ m})}{(2.0\text{ s})^2} = \boxed{6.2\text{ m/s}^2\text{ upward}}$

Givens	*Solutions*
17. $\Delta x = +42.0$ m $v_i = +153.0$ km/h $v_f = 0$ km/h	$a = \frac{v_f^2 - v_i^2}{2\Delta x} = \frac{[(0\ \text{km/h})^2 - (153.0\ \text{km/h})^2]\left(\frac{1\ \text{h}}{3600\ \text{s}}\right)^2\left(\frac{10^3\ \text{m}}{1\ \text{km}}\right)^2}{(2)\ (42.0\ \text{m})}$ $a = \frac{-(2.34 \times 10^4\ \text{km}^2/\text{h}^2)\left(\frac{1\ \text{h}}{3600\ \text{s}}\right)^2\left(\frac{10^3\ \text{m}}{1\ \text{km}}\right)^2}{(84.0\ \text{m})} = \boxed{-21.5\ \text{m/s}^2}$
18. $v_i = 17.5$ m/s $v_f = 0.0$ m/s $\Delta t_{tot} = 3.60$ s	$\Delta x = \frac{1}{2}(v_i + v_f)\Delta t$ $\Delta t_{top} = \frac{\Delta t_{tot}}{2} = \frac{3.60\ \text{s}}{2} = 1.80\ \text{s}$ $\Delta x = \frac{1}{2}(17.5\ \text{m/s} + 0.0\ \text{m/s})(1.80\ \text{s}) = \boxed{15.8\ \text{m}}$
19. $\Delta t = 5.50$ s $v_i = 0.0$ m/s $v_f = 14.0$ m/s	$\Delta x = \frac{1}{2}(v_i + v_f)\Delta t = \frac{1}{2}(0.0\ \text{m/s} + 14.0\ \text{m/s})(5.50\ \text{s}) = \boxed{38.5\ \text{m}}$
20. $v = 6.50$ m/s downward $= -6.50$ m/s $\Delta t = 34.0$ s	$\Delta x = v\Delta t = (-6.50\ \text{m/s})(34.0\ \text{s}) = \boxed{-221\ \text{m} = 221\ \text{m downward}}$
21. $v_t = 10.0$ cm/s $v_h = 20\ v_t = 2.00 \times 10^2$ cm/s $\Delta t_{race} = \Delta t_t$ $\Delta t_h = \Delta t_t - 2.00$ min $\Delta x_t = \Delta x_h + 20.0\ \text{cm} = \Delta x_{race}$	$\Delta x_t = v_t \Delta t_t$ $\Delta x_h = v_h \Delta t_h = v_h\ (\Delta t_t - 2.00\ \text{min})$ $\Delta x_t = \Delta x_{race} = \Delta x_h + 20.0\ \text{cm}$ $v_t\ \Delta t_t = v_h\ (\Delta t_t - 2.00\ \text{min}) + 20.0\ \text{cm}$ $\Delta t_t\ (v_t - v_h) = -v_h\ (2.00\ \text{min}) + 20.0\ \text{cm}$ $\Delta t_t = \frac{20.0\ \text{cm} - v_h\ (2.00\ \text{min})}{v_t - v_h}$ $\Delta t_{race} = \Delta t_t = \frac{20.0\ \text{cm} - (2.00 \times 10^2\ \text{cm/s})(2.00\ \text{min})(60\ \text{s/min})}{10.0\ \text{cm/s} - 2.00 \times 10^2\ \text{cm/s}}$ $\Delta t_{race} = \frac{20.0\ \text{cm} - 2.40 \times 10^4\ \text{cm}}{-1.90 \times 10^2\ \text{cm/s}} = \frac{-2.40 \times 10^4\ \text{cm}}{-1.90 \times 10^2\ \text{cm/s}}$ $\Delta t_{race} = \boxed{126\ \text{s}}$
22. $\Delta x_{race} = \Delta x_t$ $v_t = 10.0$ cm/s $\Delta t_t = 126$ s	$\Delta x_{race} = \Delta x_t = v_t \Delta t_t = (10.0\ \text{cm/s})(126\ \text{s}) = \boxed{1.26 \times 10^3\ \text{cm} = 12.6\ \text{m}}$
23. $v_i = 12.5$ m/s up, $v_i = +12.5$ m/s $v_f = 0$ m/s $a = 9.81\ \text{m/s}^2$ down, $a = -9.81\ \text{m/s}^2$	$v_f = v_i + a\Delta t$ $\Delta t = \frac{v_f - v_i}{a} = \frac{0\ \text{m/s} - 12.5\ \text{m/s}}{-9.81\ \text{m/s}^2} = \boxed{1.27\ \text{s}}$

I

Givens	Solutions
24. $\Delta t = 0.910$ s $\Delta x = 7.19$ km $v_i = 0$ km/s	$v_f = \frac{2\Delta x}{\Delta t} - v_i = \frac{(2)(7.19\text{ km})}{0.910\text{ s}} - 0\text{ km/s} = \boxed{15.8\text{ km/s}}$
25. $a = 3.0$ m/s^2 $\Delta t = 4.1$ s $v_f = 55.0$ km/h	$v_f = v_i + a\Delta t$ $v_i = v_f - a\Delta t = \left(\frac{55.0\text{ km}}{\text{h}}\right) - (3.0\text{ m/s}^2)(4.1\text{ s})\left(\frac{1\text{ km}}{1000\text{ m}}\right)\left(\frac{3600\text{ s}}{1\text{ h}}\right)$ $v_i = 55.0\text{ km/h} - 44\text{ km/h} = \boxed{11\text{ km/h}}$
26. $\Delta t = 1.5$ s $v_i = 2.8$ km/h $v_f = 32.0$ km/h	$a = \frac{v_f - v_i}{\Delta t} = \frac{(32.0\text{ km/h} - 2.8\text{ km/h})\left(\frac{1\text{ h}}{3600\text{ s}}\right)\left(\frac{10^3\text{ m}}{\text{km}}\right)}{1.5\text{ s}}$ $a = \frac{(29.2\text{ km/h})\left(\frac{1\text{ h}}{3600\text{ s}}\right)\left(\frac{10^3\text{ m}}{1\text{ km}}\right)}{1.5\text{ s}} = \boxed{5.4\text{ m/s}^2}$
27. $a = 4.88$ m/s^2 $\Delta x = 18.3$ m $v_i = 0$ m/s	Because $v_i = 0$ m/s, $\Delta t = \sqrt{\frac{2\Delta x}{a}} = \sqrt{\frac{(2)(18.3\text{ m})}{(4.88\text{ m/s}^2)}} = \boxed{2.74\text{ s}}$
28. $a_{avg} = 16.5$ m/s^2 $v_i = 0$ km/h $v_f = 386.0$ km/h	$\Delta t = \frac{\Delta v}{a_{avg}} = \frac{v_f - v_i}{a_{avg}} = \frac{(386.0\text{ km/h} - 0\text{ km/h})\left(\frac{1\text{ h}}{3600\text{ s}}\right)\left(\frac{10^3\text{ m}}{1\text{ km}}\right)}{16.5\text{ m/s}^2}$ $\Delta t = \frac{107.2\text{ m/s}}{16.5\text{ m/s}^2} = \boxed{6.50\text{ s}}$
29. $v_i = 50.0$ km/h forward $= +50.0$ km/h $v_f = 0$ km/h $a = 9.20$ m/s^2 backward $= -9.20$ m/s^2	$\Delta x = \frac{v_f^2 - v_i^2}{2a} = \frac{[(0\text{ km/h})^2 - (50.0\text{ km/h})^2]\left(\frac{1\text{ h}}{3600\text{ s}}\right)^2\left(\frac{10^3\text{ m}}{1\text{ km}}\right)^2}{(2)(-9.20\text{ m/s}^2)}$ $\Delta x = \frac{-(2.50 \times 10^3\text{ km}^2/\text{h}^2)\left(\frac{1\text{ h}}{3600\text{ s}}\right)^2\left(\frac{10^3\text{ m}}{1\text{ km}}\right)^2}{-18.4\text{ m/s}^2}$ $\Delta x = 10.5\text{ m} = \boxed{10.5\text{ m forward}}$
30. $v_i = -4.0$ m/s $a_{avg} = -0.27$ m/s^2 $\Delta t = 17$ s	$v_f = a_{avg}\Delta t + v_i$ $v_f = (-0.27\text{ m/s}^2)(17\text{ s}) + (-4.0\text{ m/s}) = -4.6\text{ m/s} - 4.0\text{ m/s} = \boxed{-8.6\text{ m/s}}$
31. $v_i = +4.42$ m/s $v_f = 0$ m/s $a = -0.75$ m/s^2	$\Delta t = \frac{v_f - v_i}{a} = \frac{0\text{ m/s} - 4.42\text{ m/s}}{-0.75\text{ m/s}^2} = \frac{-4.42\text{ m/s}}{-0.75\text{ m/s}^2} = \boxed{5.9\text{ s}}$

Givens	*Solutions*
32. $v_i = 4.42$ m/s $a = -0.75$ m/s^2 $\Delta t = 5.9$ s	$\Delta x = v_i \Delta t + \frac{1}{2} a \Delta t^2 = (4.42 \text{ m/s})(5.9 \text{ s}) + \frac{1}{2}(-0.75 \text{ m/s}^2)(5.9 \text{ s})^2$ $\Delta x = 26 \text{ m} - 13 \text{ m} = \boxed{13 \text{ m}}$
33. $v_i = 25$ m/s west $v_f = 35$ m/s west $\Delta x = 250$ m west	$\Delta t = \frac{2\Delta x}{v_i + v_f} = \frac{(2)(250 \text{ m})}{25 \text{ m/s} + 35 \text{ m/s}} = \frac{5.0 \times 10^2 \text{ m}}{6.0 \times 10^1 \text{ m/s}} = \boxed{8.3 \text{ s}}$
34. $a = -7.6 \times 10^{-2}$ m/s^2 $\Delta x = 255$ m $\Delta t = 82.0$ s	$v_i = v_f - a\Delta t = 0.0 \text{ m/s} - (-7.6 \times 10^{-2} \text{ m/s}^2)(82.0 \text{ s}) = \boxed{6.2 \text{ m/s}}$
35. $v_i = 4.5$ m/s $v_f = 10.8$ m/s $a_{avg} = 0.85$ m/s^2	$\Delta t = \frac{\Delta v}{a_{avg}} = \frac{v_f - v_i}{a_{avg}} = \frac{10.8 \text{ m/s} - 4.5 \text{ m/s}}{0.85 \text{ m/s}^2} = \frac{6.3 \text{ m/s}}{0.85 \text{ m/s}^2} = \boxed{7.4 \text{ s}}$
36. $v_i = 0.0$ m/s $v_f = -49.5$ m/s $a = -9.81$ m/s^2	$\Delta x = \frac{v_f^2 - v_i^2}{2a} = \frac{(-49.5 \text{ m/s})^2 - (0.0 \text{ m/s})^2}{2(-9.81 \text{ m/s}^2)} = \frac{2.45 \times 10^3 \text{ m}^2/\text{s}^2}{-19.6 \text{ m/s}^2}$ $\Delta x = \boxed{-125 \text{ m or } 125 \text{ m downward}}$
37. $v_i = +320$ km/h $v_f = 0$ km/h $\Delta t = 0.18$ s	$a_{avg} = \frac{\Delta v}{\Delta t} = \frac{v_f - v_i}{\Delta t} = \frac{(0 \text{ km/h} - 320 \text{ km/h})\left(\frac{1 \text{ h}}{3600 \text{ s}}\right)\left(\frac{10^3 \text{ m}}{1 \text{ km}}\right)}{0.18 \text{ s}}$ $a_{avg} = \frac{-89 \text{ m/s}}{0.18 \text{ s}} = \boxed{-490 \text{ m/s}^2}$
38. $a = 7.56$ m/s^2 $\Delta x = 19.0$ m $v_i = 0$ m/s	$v_f = \sqrt{v_i^2 + 2a\Delta x} = \sqrt{(0 \text{ m/s})^2 + (2)(7.56 \text{ m/s}^2)(19.0 \text{ m})}$ $v_f = \sqrt{287 \text{ m}^2/\text{s}^2} = \pm 16.9 \text{ m/s} = \boxed{16.9 \text{ m/s}}$
39. $v_i = 85.1$ m/s upward $= +85.1$ m/s $a = -9.81$ m/s^2 $\Delta x = 0$ m	Because $\Delta x = 0$ m, $v_i \Delta t + \frac{1}{2} a \Delta t^2 = 0$ $\Delta t = -\frac{2v_i}{a} = -\frac{(2)(85.1 \text{ m/s})}{(-9.81 \text{ m/s}^2)} = \boxed{17.3 \text{ s}}$
40. $v_i = 13.7$ m/s forward $= +13.7$ m/s $v_f = 11.5$ m/s backward $= -11.5$ m/s $\Delta t = 0.021$ s	$a_{avg} = \frac{\Delta v}{\Delta t} = \frac{v_f - v_i}{\Delta t} = \frac{(-11.5 \text{ m/s}) - (13.7 \text{ m/s})}{0.021 \text{ s}} = \frac{-25.2 \text{ m/s}}{0.021 \text{ s}}$ $a_{avg} = \boxed{-1200 \text{ m/s}^2, \text{ or } 1200 \text{ m/s}^2 \text{ backward}}$
41. $v_i = 1.8$ m/s $v_f = 9.4$ m/s $a = 6.1$ m/s^2	$\Delta x = \frac{v_f^2 - v_i^2}{2a} = \frac{(9.4 \text{ m/s})^2 - (1.8 \text{ m/s})^2}{(2)(6.1 \text{ m/s}^2)} = \frac{88 \text{ m}^2/\text{s}^2 - 3.2 \text{ m}^2/\text{s}^2}{(2)(6.1 \text{ m/s}^2)}$ $\Delta x = \frac{85 \text{ m}^2/\text{s}^2}{(2)(6.1 \text{ m/s}^2)} = \boxed{7.0 \text{ m}}$

Givens	*Solutions*
42. $v_i = 0$ m/s $\Delta t = 2.0$ s $a = -9.81$ m/s^2	Because $v_i = 0$ m/s, $\Delta x = \frac{1}{2}a\Delta t^2 = \frac{1}{2}(-9.81 \text{ m/s}^2)(2.0 \text{ s})^2 = -2.0 \times 10^1$ m distance of bag below balloon = $\boxed{2.0 \times 10^1 \text{ m}}$
43. $a = 0.678$ m/s^2 $v_f = 8.33$ m/s $\Delta x = 46.3$ m	$v_i = \sqrt{v_f^2 - 2a\Delta x} = \sqrt{(8.33 \text{ m/s})^2 - (2)(0.678 \text{ m/s}^2)(46.3 \text{ m})}$ $v_i = \sqrt{69.4 \text{ m}^2/\text{s}^2 - 62.8 \text{ m}^2/\text{s}^2} = \sqrt{6.6 \text{ m}^2/\text{s}^2} = \pm 2.6 \text{ m/s} = \boxed{2.6 \text{ m/s}}$
44. $v_i = 7.5$ m/s $v_f = 0.0$ m/s $a = -9.81$ m/s^2	$v_f = v_i + a\Delta t$ $\Delta \text{t} = \frac{v_f - v_i}{a} = \frac{0.0 \text{ m/s} - 7.5 \text{ m/s}}{-9.81 \text{ m/s}^2} = \boxed{0.76 \text{ s}}$
45. $v_i = 0.0$ m/s $a = -3.70$ m/s^2 $\Delta x = -17.6$ m	$v_f^2 = v_i^2 + 2a\Delta x = (0.0 \text{ m/s})^2 + 2(-3.70 \text{ m/s}^2)(-17.6\text{m}) = 130 \text{ m}^2/\text{s}^2$ $v_f = \sqrt{130 \text{ m}^2/\text{s}^2} = \boxed{11.4 \text{ m/s down}}$

Two-Dimensional Motion and Vectors

46. $d = 599$ m $\Delta y = 89$ m north	$d^2 = \Delta x^2 + \Delta y^2$ $\Delta x = \sqrt{d^2 - \Delta y^2} = \sqrt{(599 \text{ m})^2 - (89 \text{ m})^2} = \sqrt{3.59 \times 10^5 \text{ m}^2 - 7.9 \times 10^3 \text{ m}^2}$ $\Delta x = \sqrt{3.51 \times 10^5 \text{ m}^2}$ $\Delta x = \boxed{592 \text{ m, east}}$
47. $d = 599$ m $\Delta y = 89$ m north	$\theta = \sin^{-1}\left(\frac{\Delta y}{d}\right) = \sin^{-1}\left(\frac{89 \text{ m}}{599 \text{ m}}\right)$ $\theta = \boxed{8.5° \text{ north of east}}$

Givens	*Solutions*
48. $d = 478$ km $\Delta y = 42$ km, south $= -42$ km	$d^2 = \Delta x^2 + \Delta y^2$ $\Delta x = \sqrt{d^2 - \Delta y^2} = \sqrt{(478 \text{ km})^2 - (-42 \text{ km})^2}\ \sqrt{2.28 \times 10^5 \text{ km}^2 - 1.8 \times 10^3 \text{ km}^2}$ $\Delta x = \sqrt{2.26 \times 10^5 \text{ km}^2} = -475$ km $\Delta x =$ 475 km, west
49. $d = 478$ km $\Delta y = 42$ km, south $= -42$ km	$\theta = \sin^{-1}\left(\frac{\Delta y}{d}\right) = \sin^{-1}\left(\frac{-42 \text{ km}}{478 \text{ km}}\right)$ $\theta =$ 5.0° south of west
50. $d = 7400$ km $\theta = 26°$ south of west $\Delta y = 3200$ km, south $= -3200$ km	$\text{d}^2 = \Delta x^2 = \Delta y^2$ $\Delta x = \sqrt{d^2 - \Delta y^2} = \sqrt{(7400 \text{ km})^2 - (-3200 \text{ km})^2} = \sqrt{5.5 \times 10^7 \text{ km}^2 - 1.0 \times 10^7 \text{ km}^2}$ $\Delta x = \sqrt{4.5 \times 10^7 \text{ km}^2} = -6700$ km $\Delta x =$ 6700 km, west
51. $d = 5.3$ km $\theta = 8.4°$ above horizontal	$\Delta y = d(\sin \theta) = (5.3 \text{ km})(\sin 8.4°)$ $\Delta y = 0.77 \text{ km} = 770$ m the mountain's height = 770 m
52. $d = 113$ m $\theta = 82.4°$ above the horizontal south	$\Delta x = d(\cos \theta) = (113 \text{ m})(\cos 82.4°)$ $\Delta x = 14.9$ m, south
53. $v = 55$ km/h $\theta = 37°$ below the horizontal $= -37°$	$v_y = v(\sin \theta) = (55 \text{ km/h})[\sin(-37°)]$ $v_y = -33$ km/h = 33 km/h, downward

Givens	*Solutions*
54. $d_1 = 55$ km $\theta_1 = 37$ north of east $d_2 = 66$ km $\theta_2 = 0.0°$ (due east)	$\Delta x_1 = d_1(\cos\theta_1) = (55\text{ km})(\cos 37°) = 44\text{ km}$ $\Delta y_1 = d_1(\sin\theta_1) = (55\text{ km})(\sin 37°) = 33\text{ km}$ $\Delta x_2 = d_2(\cos\theta_2) = (66\text{ km})(\cos 0.0°) = 66\text{ km}$ $\Delta y_2 = d_2(\sin\theta_2) = (66\text{ km})(\sin 0.0°) = 0\text{ km}$ $\Delta x_{tot} = \Delta x_1 + \Delta x_2 = 44\text{ km} + 66\text{ km} = 110\text{ km}$ $\Delta y_{tot} = \Delta y_1 + \Delta y_2 = 33\text{ km} + 0\text{ km} = 33\text{ km}$ $d = \sqrt{(\Delta x_{tot})^2 + (\Delta y_{tot})^2} = \sqrt{(110\text{ km})^2 + (33\text{ km})^2}$ $= \sqrt{1.21 \times 10^4\text{ km}^2 + 1.1 \times 10^3\text{ km}^2} = \sqrt{1.32 \times 10^4\text{ km}^2}$ $d = \boxed{115\text{ km}}$ $\theta = \tan^{-1}\left(\frac{\Delta y_{tot}}{\Delta x_{tot}}\right) = \tan^{-1}\left(\frac{33\text{ km}}{110\text{ km}}\right)$ $\theta = \boxed{17°\text{ north of east}}$
55. $d_1 = 4.1$ km $\theta_1 = 180°$ (due west) $d_2 = 17.3$ km $\theta_2 = 90.0°$ (due north) $d_3 = 1.2$ km $\theta_3 = 24.6°$ west of north $= 90.0° + 24.6° = 114.6°$	$\Delta x_1 = d_1(\cos\Delta_1) = (4.1\text{ km})(\cos 180°) = -4.1\text{ km}$ $\Delta y_1 = d_1(\sin\theta_1) = (4.1\text{ km})(\sin 180°) = 0\text{ km}$ $\Delta x_2 = d_2(\cos\theta_2) = (17.3\text{ km})(\cos 90.0°) = 0\text{ km}$ $\Delta y_2 = d_2(\sin\theta_2) = (17.3\text{ km})(\sin 90.0°) = 17.3\text{ km}$ $\Delta x_3 = d_3(\cos\theta_3) = (1.2\text{ km})(\cos 114.6°) = -0.42\text{ km}$ $\Delta y_3 = d_3(\sin\theta_3) = (1.2\text{ km})(\sin 114.6°) = 1.1\text{ km}$ $\Delta x_{tot} = \Delta x_1 + \Delta x_2 + \Delta x_3 = -4.1\text{ km} + 0\text{ km} + (-0.42\text{ km}) = -4.5\text{ km}$ $\Delta y_{tot} = \Delta y_1 + \Delta y_2 + \Delta y_3 = 0\text{ km} + 17.3\text{ km} + 1.1\text{ km} = 18.4\text{ km}$ $d = \sqrt{(\Delta x_{tot})^2 + (\Delta y_{tot})^2} = \sqrt{(-4.5\text{ km})^2 + (18.4\text{ km})^2}$ $= \sqrt{2.0 \times 10^1\text{ km}^2 + 339\text{ km}^2} = \sqrt{359\text{ km}^2}$ $d = \boxed{18.9\text{ km}}$ $\theta = \tan^{-1}\left(\frac{\Delta y_{tot}}{\Delta x_{tot}}\right) = \tan^{-1}\left(\frac{18.4\text{ km}}{-4.5\text{ km}}\right) = -76° = \boxed{76°\text{ north of west}}$
56. $\Delta x = 125$ m $v_x = 90.0$ m/s	$\Delta x = v_x \Delta t$ $\Delta t = \frac{\Delta x}{v_x} = \frac{(125\text{ m})}{(90\text{ m/s})} = \boxed{1.39\text{ s}}$

Givens | *Solutions*

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57. $v_x = 10.0$ cm/s

$\Delta x = 18.6$ cm

$g = 9.81$ m/s^2

$$\Delta t = \frac{\Delta x}{v_x}$$

$$\Delta y = -\tfrac{1}{2}g\Delta t^2$$

$$\Delta y = -\tfrac{1}{2}g\left(\frac{\Delta x}{v_x}\right)^2 = -\tfrac{1}{2}(9.81\ \text{m/s}^2)\left(\frac{18.6\ \text{cm}}{10.0\ \text{cm/s}}\right)^2 = -17.0\ \text{m}$$

$\boxed{\text{squirrel's height} = 17.0\ \text{m}}$

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58. $v_i = 250$ m/s

$\theta = 35°$

$g = 9.81$ m/s^2

At the maximum height

$$v_{y,f} = v_{y,i} - g\Delta t = 0$$

$$v_{y,i} = v_i(\sin\theta) = g\Delta t$$

$$\Delta t = \frac{v_i(\sin\theta)}{g} = \frac{(250\ \text{m/s})(\sin 35°)}{9.81\ \text{m/s}^2}$$

$\Delta t = \boxed{15\ \text{s}}$

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59. $v_i = 23.1$ m/s

$\Delta y_{max} = 16.9$ m

$g = 9.81$ m/s^2

$$v_{y,f}^{\ 2} - v_{y,i}^{\ 2} = -2g\Delta y$$

At maximum height, $v_{y,f}$

$$v_{y,i} = v_i(\sin\theta) = \sqrt{2g\Delta y_{max}}$$

$$\theta = \sin^{-1}\left(\frac{\sqrt{2g\Delta y_{max}}}{v_i}\right) = \sin^{-1}\left[\frac{\sqrt{(2)(9.81\ \text{m/s}^2)(16.9\ \text{m})}}{23.1\ \text{m/s}}\right]$$

$\theta = \boxed{52.0°}$

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60. $\mathbf{v_{bw}} = 58.0$ km/h, forward $= +58.0$ km/h

$\mathbf{v_{we}} = 55.0$ km/h, backward $= -55.0$ km/h

$$\mathbf{v_{be}} = \mathbf{v_{bw}} + \mathbf{v_{we}} = +58.0\ \text{km/h} + (-55.0\ \text{km/h}) = +3.0\ \text{km/h}$$

$$\Delta t = \frac{\Delta x}{v_{be}} = \frac{1.4\ \text{km}}{3.0\ \text{km/h}}$$

$\Delta t = \boxed{0.47\ \text{h} = 28\ \text{min}}$

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61. $\mathbf{v_{1e}} = 286$ km/h, forward

$\mathbf{v_{2e}} = 252$ km/h, forward

$\Delta x = 0.750$ km

$$\mathbf{v_{12}} + \mathbf{v_{2e}} = \mathbf{v_{1e}}$$

$$\mathbf{v_{12}} = \mathbf{v_{1e}} - \mathbf{v_{2e}}$$

$$v_{12} = v_{1e} - v_{2e} = 286\ \text{km/h} - 252\ \text{km/h} = 34\ \text{km/h}$$

$$\Delta t = \frac{\Delta x}{v_{12}} - \frac{0.750\ \text{km}}{34\ \text{km/h}} = 2.2 \times 10^{-2}\ \text{h}$$

$$\Delta t = (2.2 \times 10^{-2}\ \text{h})\left(\frac{3600\ \text{s}}{1\ \text{h}}\right) = \boxed{79\ \text{s}}$$

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62. $\Delta x = 165$ m

$\Delta y = -45$ m

$$d = \sqrt{\Delta x^2 + \Delta y^2} = \sqrt{(165\ \text{m})^2 + (-45\ \text{m})^2}\ \sqrt{2.72 \times 10^4\ \text{m}^2 + 2.0 \times 10^3\ \text{m}^2} = \sqrt{2.92 \times 10^4\ \text{m}^2}$$

$d = \boxed{171\ \text{m}}$

$$\theta \tan^{-1}\left(\frac{\Delta y}{\Delta x}\right) = \tan^{-1}\left(\frac{-45\ \text{m}}{165\ \text{m}}\right)$$

$\theta = -15° = \boxed{15°\ \text{below the horizontal}}$

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Givens	Solutions
63. $\Delta y = -13.0$ m $\Delta x = 9.0$ m	$d = \sqrt{\Delta x^2 + \Delta y^2} = \sqrt{(9.0\text{ m})^2 + (-13.0\text{ m})^2} = \sqrt{81\text{ m}^2 + 169\text{ m}^2} = \sqrt{2.50 \times 10^2\text{ m}^2}$ $d = \boxed{15.8\text{ m}}$ $\theta = \tan^{-1}\left(\frac{\Delta y}{\Delta x}\right)\ \tan^{-1}\left(\frac{-13.0\text{ m}}{9.0\text{ m}}\right)$ $\theta = -55° = \boxed{55° \text{ below the horizontal}}$
64. $d = 2.7$ m $\theta = 13°$ from the table's length	$\Delta x = d(\cos\theta) = (2.7\text{ m})(\cos 13°)$ $\Delta x = \boxed{2.6\text{ m along the table's length}}$ $\Delta y = d(\sin\theta) = (2.7\text{ m})(\sin 13°)$ $\Delta y = \boxed{0.61\text{ m along the table's width}}$
65. $v = 1.20$ m/s $\theta = 14.0°$ east of north	$v_x = v(\sin\theta) = (1.20\text{ m/s})(\sin 14.0°)$ $v_x = \boxed{0.290\text{ m/s, east}}$ $v_y = v(\cos\theta) = (1.20\text{ m/s})(\cos 14.0°)$ $v_y = \boxed{1.16\text{ m/s, north}}$
66. $v = 55.0$ km/h $\theta = 13.0°$ above horizontal	$v_y = v(\sin\theta) = (55.0\text{ km/h})(\sin 13.0°)$ $v_y = \boxed{12.4\text{ km/h, upward}}$ $v_x = v(\cos\theta) = (55.0\text{ km/h})(\cos 13.0°)$ $v_x = \boxed{53.6\text{ km/h, forward}}$
67. $d = 3.88$ km $\Delta x = 3.45$ km $h_1 = 0.8$ km	$d^2 = \Delta x^2 + \Delta y^2$ $\Delta y = \sqrt{d^2 - \Delta x^2} = \sqrt{(3.88\text{ km})^2 - (3.45\text{ km})^2} = \sqrt{15.1\text{ km}^2 - 11.9\text{ km}^2} = \sqrt{3.2\text{ km}^2}$ $\Delta y = 1.8$ km height of mountain $= h = \Delta y + h_1 = 1.8\text{ km} + 0.8\text{ km}$ $\boxed{h = 2.6\text{ km}}$
68. $d_1 = 850$ m $\theta_1 = 0.0°$ $d_2 = 640$ m $\theta_2 = 36°$	$\Delta x_1 = d_1(\cos\theta_1) = (850\text{ m})(\cos 0.0°) = 850\text{ m}$ $\Delta y_1 = d_1(\sin\theta_1) = (850\text{ m})(\sin 0.0°) = 0\text{ m}$ $\Delta x_2 = d_2(\cos\theta_2) = (640\text{ m})(\cos 36°) = 520\text{ m}$ $\Delta y_2 = d_2(\sin\theta_2) = (640\text{ m})(\sin 36°) = 380\text{ m}$ $\Delta x_{tot} = \Delta x_1 + \Delta x_2 = 850\text{ m} + 520\text{ m} = 1370\text{ m}$ $\Delta y_{tot} = \Delta y_1 + \Delta y_2 = 0\text{ m} + 380\text{ m} = 380\text{ m}$ $d = \sqrt{(\Delta x_{tot})^2 + (\Delta y_{tot})^2} = \sqrt{(1370\text{ m})^2 + (380\text{ m})^2} = \sqrt{1.88 \times 10^6\text{ m}^2 + 1.4 \times 10^5\text{ m}^2}$ $= \sqrt{2.02 \times 10^6\text{ m}^2} = 1420\text{ m} = \boxed{1.42 \times 10^3\text{ m}}$ $\theta = \tan^{-1}\left(\frac{\Delta y_{tot}}{\Delta x_{tot}}\right) = \tan^{-1}\left(\frac{380\text{ m}}{1370\text{ m}}\right)$ $= \boxed{16° \text{ to the side of the initial dispacement}}$

Givens	Solutions
69. $d_1 = 46$ km $\theta_1 = 15°$ south of east $= -15°$ $d_2 = 22$ km $\theta_2 = 13°$ east of south $= -77°$ $d_3 = 14$ km $\theta_3 = 14°$ west of south $= -90.0° - 14° = -104°$	$\Delta x_1 = d_1(\cos\theta_1) = (46\text{ km})[\cos(-15°)] = 44\text{ km}$ $\Delta y_1 = d_1(\sin\theta_1) = (46\text{ km})[\sin(-15°)] = -12\text{ km}$ $\Delta x_2 = d_2(\cos\theta_2) = (22\text{ km})[\cos(-77°)] = 4.9\text{ km}$ $\Delta y_2 = d_2(\sin\theta_2) = (22\text{ km})[\sin(-77°)] = -21\text{ km}$ $\Delta x_3 = d_3(\cos\theta_3) = (14\text{ km})[\cos(-104°)] = -3.4\text{ km}$ $\Delta y_3 = d_3(\sin\theta_3) = (14\text{ km})[\sin(-104°)] = -14\text{ km}$ $\Delta x_{tot} = \Delta x_1 + \Delta x_2 + \Delta x_3 = 44\text{ km} + 4.9\text{ km} + (-3.4\text{ km}) = 46\text{ km}$ $\Delta y_{tot} = \Delta y_1 + \Delta y_2 + \Delta y_3 = -12\text{ km} + (-21\text{ km}) + (-14\text{ km}) = -47\text{ km}$ $d = \sqrt{(\Delta x_{tot})^2 + (\Delta y_{tot})^2} = \sqrt{(46\text{ km})^2 + (-47\text{ km})^2} = \sqrt{2.1\times10^3\text{ km}^2 + 2.2\times10^3\text{ km}^2}$ $= \sqrt{4.3\times10^3\text{ km}^2}$ $d = \boxed{66\text{ km}}$ $\theta = \tan^{-1}\left(\frac{\Delta y_{tot}}{\Delta x_{tot}}\right) = \tan^{-1}\left(\frac{-47\text{ km}}{46\text{ km}}\right) = -46°$ $\theta = \boxed{46°\text{ south of east}}$
70. $v_x = 9.37$ m/s $\Delta x = 85.0$ m $g = 9.81\text{ m/s}^2$	$\Delta t = \frac{\Delta x}{v_x}$ $\Delta y = -\frac{1}{2}g\Delta t^2$ $\Delta y = -\frac{1}{2}g\left(\frac{\Delta x}{v_x}\right)^2 = -\frac{1}{2}(9.81\text{ m/s}^2)\left(\frac{85.0\text{ m}}{9.37\text{ m/s}}\right)^2 = -404\text{ m}$ $\boxed{\text{mountain's height} = 404\text{ m}}$
71. $\Delta y = -2.50\times10^2$ m $v_x = 1.50$ m/s $g = 9.81\text{ m/s}^2$	$\Delta x = v_x\Delta t$ $\Delta y = -\frac{1}{2}g\Delta t^2$ $\Delta t = \sqrt{\frac{2\Delta y}{-g}}$ $\Delta x = v_x\sqrt{\frac{2\Delta y}{-g}} = (1.50\text{ m/s})\sqrt{\frac{(2)(-2.50\times10^2\text{ m})}{-9.81\text{ m/s}^2}}$ $\Delta x = \boxed{10.7\text{ m}}$
72. $v_x = 1.50$ m/s $\Delta y = -2.50\times10^2$ m $g = 9.81\text{ m/s}^2$	$v_{y,f}^2 = -2g\Delta y + v_{y,i}^2$ $v_{y,i} = 0$ m/s, so $v_{y,f} = v_y = \sqrt{-2g\Delta y} = \sqrt{-(2)(9.81\text{ m/s}^2)(-2.50\times10^2\text{ m})}$ $v_y = 70.0$ m/s $v = \sqrt{v_x^2 + v_y^2} = \sqrt{(1.50\text{ m/s})^2 + (70.0\text{ m/s})^2} = \sqrt{2.25\text{ m}^2/\text{s}^2 + 4.90\times10^3\text{ m}^2/\text{s}^2}$ $= \sqrt{4.90\times10^3\text{ m}^2/\text{s}^2}$ $v = \boxed{70.0\text{ m/s}}$ $\theta = \tan^{-1}\left(\frac{v_x}{v_y}\right) = \tan^{-1}\left(\frac{1.50\text{ m/s}}{70.0\text{ m/s}}\right)$ $\theta = \boxed{1.23°\text{ from the vertical}}$

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Givens	*Solutions*

73. $\theta = -30.0°$

$v_i = 2.0$ m/s

$\Delta y = -45$ m

$g = 9.81$ m/s^2

$$\Delta y = v_i(\sin\theta)\Delta t - \tfrac{1}{2}g\Delta t^2$$

$$\left(\frac{g}{2}\right)\Delta t^2 - [v_i(\sin\theta)]\Delta t + \Delta y = 0$$

Solving for Δt using the quadratic equation,

$$\Delta t = \frac{v_i(\sin\theta) \pm \sqrt{[-v_i(\sin\theta)]^2 - 4\left(\frac{g}{2}\right)(\Delta y)}}{2\left(\frac{g}{2}\right)}$$

$$\Delta t = \frac{(2.0\text{ m/s})[\sin(-30.0°)] \pm \sqrt{[(-2.0\text{ m/s})[\sin(-30.0°)]^2 - (2)(9.81\text{ m/s}^2)(-45\text{ m})}}{9.81\text{ m/s}^2}$$

$$\Delta t = \frac{-1.0\text{ m/s} \pm \sqrt{1.0\text{ m}^2/\text{s}^2 + 8.8\times 10^2\text{ m}^2/\text{s}^2}}{9.81\text{ m/s}^2} = \frac{-1.0\text{ m/s} \pm \sqrt{8.8\times 10^2\text{ m}^2/\text{s}^2}}{9.81\text{ m/s}^2}$$

$$\Delta t = \frac{-1.0\text{ m/s} \pm 3.0\times 10^1\text{ m/s}}{9.81\text{ m/s}^2}$$

Δt must be positive, so the positive root must be chosen.

$$\Delta t = \frac{29\text{ m/s}}{9.81\text{ m/s}^2} = \boxed{3.0\text{ s}}$$

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74. $v_i = 10.0$ m/s

$\theta = 37.0°$

$\Delta t = 2.5$ s

$g = 9.81$ m/s^2

$$\Delta x = v_i(\cos\theta)\Delta t = (10.0\text{ m/s})(\cos 37.0°)(2.5\text{ s})$$

$$\Delta x = \boxed{2.0\times 10^1\text{ m}}$$

$$\Delta y = v_i(\sin\theta)\Delta t - \tfrac{1}{2}g\Delta t^2 = (10.0\text{ m/s})(\sin 37.0°)(2.5\text{ s}) - \tfrac{1}{2}(9.81\text{ m/s}^2)(2.5\text{ s})^2$$

$$= 15\text{ m} - 31\text{ m}$$

$$\Delta y = \boxed{-16\text{ m}}$$

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75. $\mathbf{v_{aw}} = 55.0$ km/h, north

$\mathbf{v_{we}} = 40.0$ km/h at 17.0° north of west

$$\mathbf{v_{ae}} = \mathbf{v_{aw}} + \mathbf{v_{we}}$$

$$v_{x,\,ae} = v_{x,\,aw} + v_{x,\,we} = v_{we}(\cos\theta_{we})$$

$$v_{y,\,ae} = v_{y,\,aw} + v_{y,\,we} = v_{aw} + v_{we}(\sin\theta_{we})$$

$$\theta_{we} = 180.0° - 17.0° = 163.0°$$

$$v_{x,\,ae} = (40.0\text{ km/h})(\cos 163.0°) = -38.3\text{ km/h}$$

$$v_{y,\,ae} = 55.0\text{ km/h} + (40.0\text{ km/h})(\sin 163.0°) = 55.0\text{ km/h} + 11.7\text{ km/h} = 66.7\text{ km/h}$$

$$v_{ae} = \sqrt{(v_{x,\,ae})^2 + (v_{y,\,ae}0^2} = \sqrt{(-38.3\text{ km/h})^2 + (66.7\text{ km/h})^2}$$

$$v_{ae} = \sqrt{1.47\times 10^3\text{ km}^2/\text{h}^2 + 4.45\times 10^3\text{ km}^2/\text{h}^2} = \sqrt{5.92\times 10^3\text{ km}^2/\text{h}^2}$$

$$v_{ae} = \boxed{76.9\text{ km/h}}$$

$$\theta = \tan^{-1}\left(\frac{v_{y,ae}}{v_{x,ae}}\right) = \tan^{-1}\left(\frac{66.7\text{ km/h}}{-38.3\text{ km/h}}\right) = -60.1°$$

$$\theta = \boxed{60.1°\text{ west of north}}$$

Givens	Solutions
76. $\mathbf{v_{ae}} = 76.9$ km/h at 29.9° west of north	$\Delta x = v_{ae}(\cos\theta_{ae})\Delta t$
	$\Delta y = v_{ae}(\sin\theta_{ae})\Delta t$
$\Delta t = 15.0$ min	$\theta_{ae} = 90.0° + 29.9° = 119.9°$
	$\Delta x = (76.9\text{ km/h})(\cos 119.9°)(15.0\text{ min})(1\text{ h}/60\text{ min}) = -9.58\text{ km}$
	$\Delta y = (76.9\text{ km/h})(\sin 119.9°)(15.0\text{ min})(1\text{ h}/60\text{ min}) = 16.7\text{ km}$
	$\Delta x = \boxed{9.58\text{ km, west}}$
	$\Delta y = \boxed{16.7\text{ km, north}}$

Givens	Solutions
77. $d_1 = 2.00 \times 10^2$ m	$\Delta x_1 = d_1(\cos\theta_1) = (2.00 \times 10^2\text{ m})(\cos 0.0^2) = 2.0 \times 10^2\text{ m}$
$\theta_1 = 0.0°$	$\Delta y_1 = d_1(\sin\theta_1) = (2.00 \times 10^2\text{ m})(\sin 0.0°) = 0\text{ m}$
$d_2 = 3.00 \times 10^2$ m	$\Delta x_2 = d_2(\cos\theta_2) = (3.00 \times 10^2\text{ m})(\cos 3.0°) = 3.0 \times 10^2\text{ m}$
$\theta_2 = 3.0°$	$\Delta y_2 = d_2(\sin\theta_2) = (3.00 \times 10^2\text{ m})(\sin 3.0°) = 16\text{ m}$
$d_3 = 2.00 \times 10^2$ m	$\Delta x_3 = d_3(\cos\theta_3) = (2.00 \times 10^2\text{ m})(\cos 8.8°) = 2.0 \times 10^2\text{ m}$
$\theta_3 = 8.8°$	$\Delta y_3 = d_3(\sin\theta_3) = (2.00 \times 10^2\text{ m})(\sin 8.8°) = 31\text{ m}$
	$\Delta x_{tot} = \Delta x_1 + \Delta x_2 + \Delta x_3 = 2.0 \times 10^2\text{ m} + 3.0 \times 10^2\text{ m} + 2.0 \times 10^2\text{ m} = 7.0 \times 10^2\text{ m}$
	$\Delta y_{tot} = \Delta y_1 + \Delta y_2 + \Delta y_3 = 0\text{ m} + 16\text{ m} + 31\text{ m} = 47\text{ m}$
	$d = \sqrt{(\Delta x_{tot})^2 + (\Delta y_{tot})^2} = \sqrt{(7.0 \times 10^2\text{ m})^2 + (47\text{ m})^2} = \sqrt{4.9 \times 10^5\text{ m}^2 + 2.2 \times 10^3\text{ m}^2}$
	$= \sqrt{4.9 \times 10^5\text{ m}^2}$
	$d = \boxed{7.0 \times 10^2\text{ m}}$
	$\theta = \tan^{-1}\left(\frac{\Delta y_{tot}}{\Delta x_{tot}}\right) = \tan^{-1}\left(\frac{47\text{ m}}{7.0 \times 10^2\text{ m}}\right)$
	$\theta = \boxed{3.8°\text{ above the horizontal}}$

Givens	Solutions
78. $d_1 = 79$ km	$\Delta x_1 = d_1(\cos\theta_1) = (790\text{ km})(\cos 162°) = -750\text{ km}$
$\theta_1 = 18°$ north of west; $180.0° - 18° = 162°$	$\Delta y_1 = d_1(\sin\theta_1) = (790\text{ km})(\sin 162°) = 24\text{ km}$
$d_2 = 150$ km	$\Delta x_2 = d_2(\cos\theta_2) = (150\text{ km})(\cos 180.0°) = -150\text{ km}$
$\theta_2 = 180.0°$ due west	$\Delta y_2 = d_2(\sin\theta_2) = (150\text{ km})(\sin 180.0°) = 0\text{ km}$
$d_3 = 470$ km	$\Delta x_3 = d_3(\cos\theta_3) = (470\text{ km})(\cos 90.0°) = 0\text{ km}$
$\theta_3 = 90.0°$ due north	$\Delta y_3 = d_3(\sin\theta_3) = (470\text{ km})(\sin 90.0°) = 470\text{ km}$
$d_4 = 240$ km	$\Delta x_4 = d_4(\cos\theta_4) = (240\text{ km})(\cos 75°) = 62\text{ km}$
$\theta_4 = 15°$ east of north; $90.0° - 15° = 75°$	$\Delta y_4 = d_4(\sin\theta_4) = (240\text{ km})(\sin 75°) = 230\text{ km}$
	$\Delta x_{tot} = \Delta x_1 + \Delta x_2 + \Delta x_3 + \Delta x_4 = (-750\text{ km}) + (-150\text{ km}) + 0\text{ km} + 62\text{ km} = -840\text{ km}$
	$\Delta y_{tot} = \Delta y_1 + \Delta y_2 + \Delta y_3 + \Delta y_4 = 240\text{ km} + 0\text{ km} + 470\text{ km} + 230\text{ km} = 940\text{ km}$
	$d = \sqrt{(\Delta x_{tot})^2 + (\Delta y_{tot})^2} = \sqrt{(-840\text{ km})^2 + (940\text{ km})^2} = \sqrt{7.1 \times 10^5\text{ km}^2 + 8.8 \times 10^5\text{ km}^2}$
	$= \sqrt{15.9 \times 10^5\text{ km}^2}$
	$d = \boxed{1260\text{ km}}$
	$\theta = \tan^{-1}\left(\frac{\Delta y_{tot}}{\Delta x_{tot}}\right) = \tan^{-1}\left(\frac{940\text{ km}}{-840\text{ km}}\right) = -48°$
	$\theta = \boxed{48°\text{ north of west}}$

Givens | *Solutions*

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79. $v_x = 85.3$ m/s

$\Delta y = -1.50$ m

$g = 9.81$ m/s^2

$$\Delta t = \sqrt{\frac{2\Delta y}{-g}} = \frac{\Delta x}{v_x}$$

$$\Delta x = v_x \sqrt{\frac{2\Delta y}{-g}} = (85.3 \text{ m/s}) \sqrt{\frac{(2)(-1.50 \text{ m})}{-9.81 \text{ m/s}^2}} = 47.2 \text{ m}$$

$$\boxed{\text{range of arrow} = 47.2 \text{ m}}$$

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80. $\Delta t = 0.50$ s

$\Delta x = 1.5$ m

$\theta = 33°$

$$\Delta x = v_i(\cos\theta)\Delta t$$

$$v_i = \frac{\Delta x}{(\cos\theta)\Delta t} = \frac{1.5 \text{ m}}{(\cos 33°)(0.50 \text{ s})} = \boxed{3.6 \text{ m/s}}$$

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81. $\Delta x_1 = 0.46$ m

$\Delta x_2 = 4.00$ m

$\theta = 41.0°$

$\Delta y = -0.35$ m

$g = 9.81$ m/s^2

$$\Delta x_{tot} = \Delta x_1 + \Delta x_2$$

$$\Delta t = \frac{\Delta x}{v_i(\cos\theta)}$$

$$\Delta y = v_i(\sin\theta)\Delta t - \tfrac{1}{2}g\Delta t^2 = v_i(\sin\theta)\left[\frac{\Delta x_i + \Delta x_2}{v_i(\cos\theta)}\right] - \tfrac{1}{2}g\left[\frac{\Delta x_1 + \Delta x_2}{v_i(\cos\theta)}\right]^2$$

$$\Delta y = (\Delta x_1 + \Delta x_2)(\tan\theta) - \frac{g(\Delta x_1 + \Delta x_2)^2}{2\,v_i^2(\cos\theta)^2}$$

$$v_i = \sqrt{\frac{g(\Delta x_1 + \Delta x_2)^2}{2(\cos\theta)^2[(\Delta x_1 + \Delta x_2)(\tan\theta) - \Delta y]}}$$

$$v_i = \sqrt{\frac{(9.81 \text{ m/s}^2)(0.46 \text{ m} + 4.00 \text{ m})^2}{(2)(\cos 41.0°)^2\,[(0.46 \text{ m} + 4.00 \text{ m})(\tan 41.0°) - (-0.35 \text{ m})]}}$$

$$v_i = \sqrt{\frac{(9.81 \text{ m/s}^2)(4.46 \text{ m})^2}{(2)(\cos 41.0°)^2(3.88 \text{ m} + 0.35 \text{ m})}}$$

$$v_i = \sqrt{\frac{(9.81 \text{ m/s}^2)(4.46 \text{ m})^2}{(2)(\cos 41.0°)^2\,(4.23 \text{ m})}}$$

$$v_i = \boxed{6.36 \text{ m/s}}$$

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82. $\mathbf{v_{fc}} = 87$ km/h, west

$\mathbf{v_{ce}} = 145$ km/h, north

$\Delta t = 0.45$ s

$$\mathbf{v_{fe}} = \mathbf{v_{fc}} + \mathbf{v_{ce}}$$

$$v_{x,\,fe} = v_{x,\,fc} + v_{x,\,ce} = v_{fc} = -87 \text{ km/h}$$

$$v_{y,\,fe} = v_{y,\,fc} + v_{y,\,ce} = v_{ce} = +145 \text{ km/h}$$

$$\Delta x = v_{x,\,fe}\,\Delta t = (-87 \text{ km/h})(10^3 \text{ m/km})(1 \text{ h}/3600 \text{ s})(0.45 \text{ s}) = -11 \text{ m}$$

$$\Delta x = \boxed{\text{11m, west}}$$

$$\Delta y = v_{y,\,fe}\,\Delta t = (145 \text{ km/h})(10^3 \text{ m/km})(1 \text{ h}/3600 \text{ s})(0.45 \text{ s})$$

$$\Delta y = \boxed{\text{18 m, north}}$$

Givens | *Solutions*

83. $\mathbf{v_{bw}}$ = 12.0 km/h, south

$\mathbf{v_{we}}$ = 4.0 km/h at 15.0° south of east

$\mathbf{v_{be}} = \mathbf{v_{bw}} + \mathbf{v_{we}}$

$v_{x,\,be} = v_{x,\,bw} + v_{x,\,we} = v_{we}(\cos\theta_{we})$

$v_{y,\,be} = v_{y,\,bw} + v_{y,\,we} = v_{bw} + v_{we}(\sin\theta_{we})$

$\theta_{we} = -15.0°$

$v_{x,\,be} = (4.0 \text{ km/h})[\cos(-15.0°)] = 3.9 \text{ km/h}$

$v_{y,\,be} = (-12.0 \text{ km/h}) + (4.0 \text{ km/h})[\sin(-15.0°)] = (-12.0 \text{ km/h}) + (-1.0 \text{ km/h})$
$= -13.0 \text{ km/h}$

$v_{be} = \sqrt{(v_{x,\,be})^2 + v_{y,\,be})^2} = \sqrt{(3.9 \text{ km/h})^2 + (-13.0 \text{ km/h})^2}$

$v_{be} = \sqrt{15 \text{ km}^2/\text{h}^2 + 169 \text{ km}^2/\text{h}^2} = \sqrt{184 \text{ km}^2/\text{h}^2}$

$v_{be} = \boxed{13.6 \text{ km/h}}$

$\theta = \tan^{-1}\left(\frac{v_{y,\,be}}{v_{x,\,be}}\right) = \tan^{-1}\left(\frac{-13.0 \text{ km/h}}{3.9 \text{ km/h}}\right) = -73°$

$\theta = \boxed{73° \text{ south of east}}$

Forces and the Laws of Motion

84. $\mathbf{F_1} = 7.5 \times 10^4$ N north

$\mathbf{F_2} = 9.5 \times 10^4$ N at 15.0° north of west

$\theta_1 = 90.0°$

$\theta_2 = 180.0° - 15.0° = 165.0°$

$F_{x,net} = \Sigma F_x = F_1(\cos\theta_1) + F_2(\cos\theta_2)$

$F_{x,net} = (7.5 \times 10^4 \text{ N})(\cos 90.0°) + (9.5 \times 10^4 \text{ N})(\cos 165.0°)$

$F_{x,net} = -9.2 \times 10^4 \text{ N}$

$F_{y,net} = \Sigma F_y = F_1(\sin\theta_1) + F_2(\sin\theta_2)$

$F_{y,net} = (7.5 \times 10^4 \text{ N})(\sin 90.0°) + (9.5 \times 10^4 \text{ N})(\sin 165.0°)$

$F_{y,net} = 7.5 \times 10^4 \text{ N} + 2.5 \times 10^4 \text{ N} = 10.0 \times 10^4 \text{ N}$

$\theta = \tan^{-1}\left(\frac{F_{y,net}}{F_{x,net}}\right) = \tan^{-1}\left(\frac{10.0 \times 10^4 \text{ N}}{-9.2 \times 10^4}\right) = -47°$

$\theta = \boxed{47° \text{ north of west}}$

85. $F = 76$ N

$\theta = 40.0°$

$F_x = F(\cos\theta) = (76 \text{ N})(\cos 40.0°)$

$F_x = \boxed{58 \text{ N}}$

86. $F = 76$ N

$\theta = 40.0°$

$F_y = F(\sin\theta) = (76 \text{ N})(\sin 40.0°)$

$F_y = \boxed{49 \text{ N}}$

87. $\mathbf{F_1} = 6.0$ N

$\mathbf{F_2} = 8.0$ N

$F_{max} = F_1 + F_2 = 6.0 \text{ N} + 8.0 \text{ N}$

$F_{max} = \boxed{14.0 \text{ N}}$

$F_{min} = F_2 - F_1 = 8.0 \text{ N} - 6.0 \text{ N}$

$F_{min} = \boxed{2.0 \text{ N}}$

88. $m = 214$ kg

$F_{buoyant} = 790$ N

$g = 9.81 \text{ m/s}^2$

$F_{net} = F_{buoyant} - mg = 790 \text{ N} - (214 \text{ kg})(9.81 \text{ m/s}^2)$

$F_{net} = 790 \text{ N} - 2.10 \times 10^3 \text{ N} = -1310 \text{ N}$

$a_{net} = \frac{F_{net}}{m} = \frac{-1310 \text{ N}}{214 \text{ kg}} = \boxed{-6.12 \text{ m/s}^2}$

Givens	Solutions
89. $F_{net} = 2850$ N $v_f = 15$ cm/s $v_i = 0$ cm/s $\Delta t = 5.0$ s	$a_{net} = \frac{v_f - v_i}{\Delta t} = \frac{15\text{ cm/s} - 0\text{ cm/s}}{5.0\text{ s}} = 3.0\text{ cm/s}^2 = 3.0 \times 10^{-2}\text{ m/s}^2$ $F_{net} = m\,a_{net}$ $m = \frac{F_{net}}{a_{net}} = \frac{2850\text{ N}}{3.0 \times 10^{-2}\text{ m/s}^2}$ $m = \boxed{9.5 \times 10^4\text{ kg}}$
90. $m = 8.0$ kg $\Delta y = 20.0$ cm $\Delta t = 0.50$ s $v_i = 0$ m/s $g = 9.81\text{ m/s}^2$	$\Delta y = v_i \Delta t + \frac{1}{2} a_{net}\,\Delta t^2$ Because $v_i = 0$ m/s, $a_{net} = \frac{2\Delta y}{\Delta t^2} = \frac{(2)(20.0 \times 10^{-2}\text{ m})}{(0.50\text{ s})^2} = 1.6\text{ m/s}^2$ $F_{net} = m\,a_{net} = (8.0\text{ kg})(1.6\text{ m/s}^2) = 13$ N $F_{net} = \boxed{13\text{ N upward}}$
91. $m = 90.0$ kg $\theta = 17.0°$ $g = 9.81\text{ m/s}^2$	$F_{net} = mg(\sin\theta) - F_k = 0$ $F_k = mg(\sin\theta) = (90.0\text{ kg})(9.81\text{ m/s}^2)(\sin 17.0°) = 258$ N $F_k = \boxed{258\text{ N up the slope}}$
92. $\theta = 5.0°$	$F_{net} = mg(\sin\theta) - F_k = 0$ $F_k = \mu_k F_n = \mu_k\,mg(\cos\theta)$ $\mu_k = \frac{mg(\sin\theta)}{mg(\cos\theta)} = \tan\theta = \tan 5.0°$ $\mu_k = \boxed{0.087}$
93. $m = 2.00$ kg $\theta = 36.0°$ $a_g = 9.81\text{ m/s}^2$	$F_n = ma_g\cos\theta = (2.00\text{ kg})(9.81\text{ m/s}^2)(\cos 36.0°) = \boxed{15.9\text{ N}}$
94. $m = 1.8 \times 10^3$ kg $\theta = 15.0°$ $F_{s,max} = 1.25 \times 10^4$ N $g = 9.81\text{ m/s}^2$	$F_{s,max} = \mu_s F_n = \mu_s\,mg(\cos\theta)$ $\mu_s = \frac{F_{s,max}}{mg(\cos\theta)} = \frac{1.25 \times 10^4\text{ N}}{(1.8 \times 10^3\text{ kg})(9.81\text{ m/s}^2)(\cos 15.0°)}$ $\mu_s = \boxed{0.73}$
95. $\mu_k = 0.20$ $g = 9.81\text{ m/s}^2$	$F_{net} = m\,a_{net} = F_k$ $F_k = \mu_k F_h = \mu_k mg$ $a_{net} = \frac{\mu_k mg}{m} = \mu_k g = (0.20)(9.81\text{ m/s}^2)$ $a_{net} = \boxed{2.0\text{ m/s}^2}$

Givens	Solutions
96. $F_{applied} = 5.0$ N to the left $m = 1.35$ kg $a_{net} = 0.76\ m/s^2$ to the left	$F_{net} = m\,a_{net} = F_{applied} - F_k$ $F_k = F_{applied} - m\,a_{net}$ $F_k = 5.0\ N - (1.35\ kg)(0.76\ m/s^2) = 5.0\ N - 1.0\ N = 4.0\ N$ $F_k = \boxed{4.0\ \text{N to the right}}$
97. $F_1 = 15.0$ N $\theta = 55.0°$	$F_y = F(\sin\theta) = (15.0\ N)(\sin 55.0°)$ $F_y = \boxed{12.3\ N}$ $F_x = F(\cos\theta) = (15.0\ N)(\cos 55.0°)$ $F_x = \boxed{8.60\ N}$
98. $\mathbf{F_1} = 6.00 \times 10^2$ N north $\mathbf{F_2} = 7.50 \times 10^2$ N east $\mathbf{F_3} = 6.75 \times 10^2$ N at 30.0° south of east $\theta_1 = 90.0°$ $\theta_2 = 0.00°$ $\theta_3 = -30.0°$	$F_{x,net} = \Sigma F_x = F_1(\cos\theta_1) + F_2(\cos\theta_2) + F_3(\cos\theta_3) = (6.00 \times 10^2\ N)(\cos 90.0°) + (7.50 \times 10^2\ N)(\cos 0.00°) + (6.75 \times 10^2\ N)[\cos(-30.0°)]$ $F_{x,net} = 7.50 \times 10^2\ N + 5.85 \times 10^2\ N = 13.35 \times 10^2\ N$ $F_{y,net} = \Sigma F_y = F_1(\sin\theta_1) + F_2(\sin\theta_2) + F_3(\sin\theta_3) = (6.00 \times 10^2\ N)(\sin 90.0°) + (7.50 \times 10^2\ N)(\sin 0.00°) + (6.75 \times 10^2\ N)[\sin(-30.0°)]$ $F_{y,net} = 6.00 \times 10^2\ N + (-3.38 \times 10^2\ N) = 2.62 \times 10^2\ N$ $\theta = \tan^{-1}\left(\frac{F_{y,net}}{F_{x,net}}\right) = \tan^{-1}\left(\frac{2.62 \times 10^2\ N}{13.35 \times 10^2\ N}\right)$ $\theta = \boxed{11.1°\ \text{north of east}}$
99. $F_{net} = -65.0$ N $m = 0.145$ kg	$a_{net} = \frac{F_{net}}{m} = \frac{-65.0\ N}{0.145\ kg} = \boxed{-448\ m/s^2}$
100. $m = 2.0$ kg $\Delta y = 1.9$ m $\Delta t = 2.4$ s $v_i = 0$ m/s	$\Delta y = v_i\Delta t + \frac{1}{2}a_{net}\,\Delta t^2$ Because $v_i = 0$ m/s, $a_{net} = \frac{2\Delta y}{\Delta t^2} = \frac{(2)(1.9\ m)}{(2.4\ s)^2} = 0.66\ m/s^2$ $F_{net} = m\,a_{net} = (2.0\ kg)(0.66\ m/s) = 1.3\ N$ $F_{net} = \boxed{1.3\ \text{N upward}}$
101. $\Delta t = 1.0$ m/s $\Delta t = 5.0$ s $F_{downhill} = 18.0$ N $F_{uphill} = 15.0$ N	$a_{net} = \frac{\Delta v}{\Delta t} = \frac{1.0\ m/s}{5.0\ s} = 0.20\ m/s^2$ $F_{net} = m\,a_{net} = F_{downhill} - F_{uphill} = 18.0\ N - 15.0\ N = 3.0\ N$ $m = \frac{F_{net}}{a_{net}} = \frac{3.0\ N}{0.20\ m/s^2} = \boxed{15\ kg}$
102. $m_{sled} = 47$ kg $m_{supplies} = 33$ kg $\mu_k = 0.075$ $\theta = 15°$	$F_k = \mu_k F_n = \mu_k(m_{sled} + m_{supplies})g(\cos\theta) = (0.075)(47\ kg + 33\ kg)(9.81\ m/s^2)(\cos 15°)$ $F_k = (0.075)(8.0 \times 10^1\ kg)(9.81\ m/s^2)(\cos 15°) = \boxed{57\ N}$

Givens	Solutions
103. $a_{net} = 1.22\ m/s^2$ $\theta = 12.0°$ $g = 9.81\ m/s^2$	$F_{net} = m\,a_{net} = mg(\sin\theta) - F_k$ $F_k = \mu_k F_n = \mu_k\,mg(\cos\theta)$ $m\,a_{net} + \mu_k\,mg(\cos\theta) = mg(\sin\theta)$ $\mu_k = \frac{g(\sin\theta) - a_{net}}{g(\cos\theta)} = \frac{(9.81\ m/s^2)(\sin 12.0°) - 1.22\ m/s^2}{(9.81\ m/s^2)(\cos 12.0°)} = \frac{2.04\ m/s^2 - 1.22\ m/s^2}{(9.81\ m/s^2)(\cos 12.0°)}$ $\mu_k = \frac{0.82\ m/s^2}{(9.81\ m/s^2)(\cos 12.0°)} = \boxed{0.085}$
104. $F_{applied} = 1760\ N$ $\theta = 17.0°$ $m = 266\ kg$ $g = 9.81\ m/s^2$	$F_{net} = F_{applied} - mg(\sin\theta) - F_{s,max} = 0$ $F_{s,max} = \mu_s F_n = \mu_s\,mg(\cos\theta)$ $\mu_s\,mg(\cos\theta) = F_{applied} - mg(\sin\theta)$ $\mu_s = \frac{F_{applied} - mg(\sin\theta)}{mg(\cos\theta)} = \frac{1760 - (266\ kg)(9.81\ m/s^2)(\sin 17°)}{(266\ kg)(9.81\ m/s^2)(\cos 17°)}$ $\mu_s = \frac{1760 - 760\ N}{(266\ kg)(9.81\ m/s^2)(\cos 17°)} = \frac{1.00 \times 10^3\ N}{(266\ kg)(9.81\ m/s^2)(\cos 17°)}$ $\mu_s = \boxed{0.40}$
105. $F_{downward} = 4.26 \times 10^7\ N$ $\mu_k = 0.25$	$F_{net} = F_{downward} - F_k = 0$ $F_k = \mu_k F_n = F_{downward}$ $F_n = \frac{F_{downward}}{\mu_k} = \frac{4.26 \times 10^7\ N}{0.25} = \boxed{1.7 \times 10^8\ N}$
106. $F_n = 1.7 \times 10^8\ N$ $\theta = 10.0°$ $g = 9.81\ m/s^2$	$F_n = mg(\cos\theta)$ $m = \frac{F_n}{g(\cos\theta)} = \frac{1.7 \times 10^8\ N}{(9.81\ m/s^2)(\cos 10.0°)} = \boxed{1.8 \times 10^7\ kg}$
107. $F_{applied} = 2.50 \times 10^2\ N$ $m = 65.0\ kg$ $\theta = 18.0°$ $a_{net} = 0.44\ m/s^2$	$F_{net} = m\,a_{net} = F_{applied} - mg(\sin\theta) - F_k$ $F_k = F_{applied} - mg(\sin\theta) - ma_{net}$ $F_k = 2.50 \times 10^2\ N - (65.0\ kg)(9.81\ m/s^2)(\sin 18.0°) - (65.0\ kg)(0.44\ m/s^2)$ $F_k = 2.50 \times 10^2\ N - 197\ N - 29\ N = 24\ N = \boxed{24\ N\ downhill}$
108. $\mathbf{F_1} = 2280.0$ N upward $\mathbf{F_2} = 2250.0$ N downward $\mathbf{F_3} = 85.0$ N west $\mathbf{F_4} = 12.0$ N east	$F_{y,net} = \Sigma F_y = F_1 + F_2 = 2280.0\ N + (-2250.0\ N) = 30.0\ N$ $F_{x,net} = \Sigma F_x = F_3 + F_4 = -85.0\ N + 12.0\ N = -73.0\ N$ $\theta = \tan^{-1}\left(\frac{F_{y,net}}{F_{x,net}}\right) = \tan^{-1}\left(\frac{30.0\ N}{-73.0\ N}\right) = -22.3°$ $\theta = \boxed{22.3°\ up\ from\ west}$
109. $F_1 = 7.50 \times 10^2\ N$ $\theta_1 = 40.0°$ $F_2 = 7.50 \times 10^2\ N$ $\theta_2 = -40.0°$	$F_{y,net} = F_g = F_1(\cos\theta_1) + F_2(\cos\theta_2)$ $F_{y,net} = (7.50 \times 10^2\ N)(\cos 40.0°) + (7.50 \times 10^2\ N)\,[\cos(-40.0°)]$ $F_g = 575\ N + 575\ N = \boxed{1.150 \times 10^3\ N}$

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Givens	Solutions
110. $F_{max} = 4.5 \times 10^4$ N $a_{net} = 3.5$ m/s^2 $g = 9.81$ m/s^2	$F_{net} = m\,a_{net} = F_{max} - mg$ $m(a_{net} + g) = F_{max}$ $m = \dfrac{F_{max}}{a_{net} + g} = \dfrac{4.5 \times 10^4 \text{ N}}{3.5 \text{ m/s}^2 + 9.81 \text{ m/s}^2} = \dfrac{4.5 \times 10^4 \text{ N}}{13.3 \text{ m/s}^2} = \boxed{3.4 \times 10^3 \text{ kg}}$
111. $F_{s,max} = 2400$ N $\mu s = 0.20$ $\theta = 30.0°$ $g = 9.81$ m/s^2	$F_{s,max} = \mu_s F_n$ $F_n = \dfrac{F_{s,max}}{\mu_s} = \dfrac{2400 \text{ N}}{0.20} = 1.2 \times 10^4$ N $F_n = \boxed{1.2 \times 10^4 \text{ N perpendicular to and away from the incline}}$
112. $F_{s,max} = 2400$ N $\mu s = 0.20$ $\theta = 30.0°$ $g = 9.81$ m/s^2	$F_n = mg(\cos\theta)$ $m = \dfrac{F_n}{g(\cos\theta)} = \dfrac{1.2 \times 10^4 \text{ N}}{(9.81 \text{ m/s}^2)(\cos 30.0°)} = \boxed{1400 \text{ kg}}$
113. $m = 5.1 \times 10^2$ kg $\theta = 14°$ $F_{applied} = 4.1 \times 10^3$ N $g = 9.81$ m/s^2	$F_{net} = F_{applied} - mg(\sin\theta) - F_{s,max} = 0$ $F_{s,max} = \mu_s F_n = \mu_s mg(\cos\theta)$ $\mu_s mg(\cos\theta) = F_{applied} - mg(\sin\theta)$ $\mu_s = \dfrac{F_{applied} - mg(\sin\theta)}{mg(\cos\theta)} = \dfrac{4.1 \times 10^3 \text{ N} - (5.1 \times 10^2 \text{ kg})(9.81 \text{ m/s}^2)(\sin 14°)}{(5.1 \times 10^2 \text{ kg})(9.81 \text{ m/s}^2)(\cos 14°)}$ $\mu_s = \dfrac{4.1 \times 10^3 \text{ N} - 1.2 \times 10^3 \text{ N}}{(5.1 \times 10^2 \text{ kg})(9.81 \text{ m/s}^2)(\cos 14°)} = \dfrac{2.9 \times 10^3 \text{ N}}{(5.1 \times 10^2 \text{ kg})(9.81 \text{ m/s}^2)(\cos 14°)}$ $\mu_s = \boxed{0.60}$

Work and Energy

Givens	Solutions
114. $d = 3.00 \times 10^2$ m $W = 2.13 \times 10^6$ J $\theta = 0°$	$F = \dfrac{W}{d(\cos\theta)} = \dfrac{2.13 \times 10^6 \text{ J}}{(3.00 \times 10^2 \text{ m})(\cos 0°)} = \boxed{7.10 \times {}^3 \text{ N}}$
115. $F = 715$ N $W = 2.72 \times 10^4$ J $\theta = 0°$	$d = \dfrac{W}{F(\cos\theta)} = \dfrac{2.72 \times 10^4 \text{ J}}{(715 \text{ N})(\cos 0°)} = \boxed{38.0 \text{ m}}$
116. $v_1 = 88.9$ m/s $v_f = 0$ m/s $\Delta t = 0.181$ s $d = 8.05$ m $m = 70.0$ kg $\theta = 180°$	$W = Fd(\cos\theta)$ $F = ma$ $a = \dfrac{\Delta v}{\Delta t} = \dfrac{v_f - v_i}{\Delta t}$ $W = \dfrac{m(v_f - v_i)}{\Delta t} d(\cos\theta) = \dfrac{(70.0 \text{ kg})(0 \text{ m/s} - 88.9 \text{ m/s})}{(0.181 \text{ s})}(8.05 \text{ m})(\cos 180°)$ $W = \dfrac{(70.0 \text{ kg})(88.9 \text{ m/s})(8.05 \text{ m})}{(0.181 \text{ s})}$ $W = \boxed{2.77 \times 10^5 \text{ J}}$

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Givens	Solutions
117. $v = 15.8$ km/s $m = 0.20$ g	$KE = \frac{1}{2}mv^2 = \frac{1}{2}(0.20 \times 10^{-3}\text{ kg})(15.8 \times 10^3\text{ m/s})^2$ $KE = \boxed{2.5 \times 10^4\text{ J}}$
118. $v = 35.0$ km/h $m = 9.00 \times 10^2$ kg	$KE = \frac{1}{2}mv^2 = \frac{1}{2}(9.00 \times 10^2\text{ kg})\ [(35.0\text{ km/h})(10^3\text{ m/km})(1\text{ h}/3600\text{ s})]^2$ $KE = \boxed{4.25 \times 10^4\text{ J}}$
119. $KE = 1433$ J $m = 47.0$ g	$v = \sqrt{\frac{2\,KE}{m}} = \sqrt{\frac{(2)(1433\text{ J})}{47.0 \times 10^{-3}\text{ kg}}} = \boxed{247\text{ m/s}}$
120. $v = 9.78$ m/s $KE = 6.08 \times 10^4$ J	$m = \frac{2\,KE}{v^2} = \frac{(2)(6.08 \times 10^4\text{ J})}{(9.78\text{ m/s})^2} = \boxed{1.27 \times 10^3\text{ kg}}$
121. $m = 50.0$ kg $v_i = 47.00$ m/s $v_f = 5.00$ m/s	$W_{net} = \Delta KE = KE_f - KE_i = \frac{1}{2}mv_f^2 - \frac{1}{2}mv_i^2$ $W_{net} = \frac{1}{2}m(v_f^2 - v_i^2) = \frac{1}{2}(50.0\text{ kg})[(5.00\text{ m/s})^2 - (47.00\text{ m/s})^2]$ $W_{net} = \frac{1}{2}(50.0\text{ kg})(25.0\text{ m}^2/\text{s}^2 - 2209\text{ m}^2/\text{s}^2) = \frac{1}{2}(50.0\text{ kg})(-2184\text{ m}^2/\text{s}^2)$ $W_{net} = \boxed{-5.46 \times 10^4\text{ J}}$
122. $m = 1100$ kg $v_i = 48.0$ km/h $v_f = 59.0$ km/h $d = 100$ m	$v_i = \left(\frac{48.0\text{ km}}{\text{h}}\right)\left(\frac{1000\text{ m}}{1\text{ km}}\right)\left(\frac{1\text{ h}}{3600\text{ s}}\right) = 13.3\text{ m/s}$ $v_f = \left(\frac{59.0\text{ km}}{\text{h}}\right)\left(\frac{1000\text{ m}}{1\text{ km}}\right)\left(\frac{1\text{ h}}{3600\text{ s}}\right) = 16.4\text{ m/s}$ $\Delta KE = \frac{1}{2}m(v_f^2 - v_i^2) = \frac{1}{2}(1100\text{ kg})[(16.4)^2 - (13.3)^2]$ $\Delta KE = (550\text{ kg})(269\text{ m}^2/\text{s}^2 - 177\text{ m}^2/\text{s}^2) = (550\text{ kg})(92\text{ m}^2/\text{s}^2) = 5.1 \times 10^4\text{ J}$ $F = \frac{W}{d} = \frac{\Delta KE}{d} = \frac{5.1 \times 10^4\text{ J}}{100\text{ m}} = \boxed{5.1 \times 10^2\text{ N}}$
123. $h = 5334$ m $m = 64.0$ kg $g = 9.81\text{ m/s}^2$	$PE_g = mgh = (64.0\text{ kg})(9.81\text{ m/s}^2)(5334\text{ m}) = \boxed{3.35 \times 10^6\text{ J}}$
124. $k = 550$ N/m $x = -1.2$ cm	$PE_{elastic} = \frac{1}{2}kx^2 = \frac{1}{2}(550\text{ N/m})(-1.2 \times 10^{-2}\text{ m})^2 = \boxed{4.0 \times 10^{-2}\text{ J}}$
125. $m = 0.500$ g $h = 0.250$ km $g = 9.81\text{ m/s}^2$	$PE_i = KE_f$ $mgh = KE_f$ $KE_f = (0.500 \times 10^{-3}\text{ kg})(9.81\text{ m/s}^2)(0.250 \times 10^3\text{ m}) = \boxed{1.23\text{ J}}$

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126. $m = 50.0$ g $v_i = 3.00 \times 10^2$ m/s $v_f = 89.0$ m/s	$ME_i + \Delta ME = ME_f$ $ME_i = KE_i = \frac{1}{2}mv_i^2$ $ME_f = KE_f = \frac{1}{2}mv_f^2$ $\Delta ME = ME_f - ME_i = \frac{1}{2}m(v_f^2 - v_i^2)$ $\Delta ME = \frac{1}{2}(50.0 \times 10^{-3}\text{ kg})[(89.0\text{ m/s})^2 - (3.00 \times 10^2\text{ m/s})^2]$ $\Delta ME = \frac{1}{2}(5.00 \times 10^{-2}\text{ kg})(7.92 \times 10^3\text{ m}^2/\text{s}^2 - 9.00 \times 10^4\text{ m}^2/\text{s}^2)$ $\Delta ME = \frac{1}{2}(5.00 \times 10^{-2}\text{ kg})(-8.21 \times 10^4\text{ m}^2/\text{s}^2)$ $\Delta ME = \boxed{-2.05 \times 10^3\text{ J}}$
127. $P = 380.3$ kW $W = 4.5 \times 10^6$ J	$\Delta t = \frac{W}{P} = \frac{4.5 \times 10^6\text{ J}}{380.3 \times 10^3\text{ W}} = \boxed{12\text{ s}}$
128. $P = 13.0$ MW $\Delta t = 15.0$ min	$W = P\Delta t = (13.0 \times 10^6\text{ W})(15.0\text{ min})(60\text{ s/min}) = \boxed{1.17 \times 10^{10}\text{ J}}$
129. $F_{net} = 7.25 \times 10^{-2}$ N $W_{net} = 4.35 \times 10^{-2}$ J $\theta = 0°$	$d = \frac{W_{net}}{F_{net}(\cos\theta)} = \frac{4.35 \times 10^{-2}\text{ J}}{(7.25 \times 10^{-2}\text{ N})(\cos 0°)} = \boxed{0.600\text{ m}}$
130. $d = 76.2$ m $W_{net} = 1.31 \times 10^3$ J $\theta = 0°$	$F_{net} = \frac{W_{net}}{d(\cos\theta)} = \frac{1.31 \times 10^3\text{ J}}{(76.2\text{ m})(\cos 0°)} = \boxed{17.2\text{ N}}$
131. $d = 15.0$ m $F_{applied} = 35.0$ N $\theta_1 = 20.0°$ $F_k = 24.0$ N $\theta_2 = 180°$	$W_{net} = F_{applied}\, d(\cos\theta_1) + F_k\, d(\cos\theta_2)$ $W_{net} = (35.0\text{ N})(15.0\text{ m})(\cos 20.0°) + (24.0\text{ N})(15.0\text{ m})(\cos 180°)$ $W_{net} = 493\text{ J} + (-3.60 \times 10^2\text{ J})$ $W_{net} = \boxed{133\text{J}}$
132. $m = 7.5 \times 10^7$ kg $v = 57$ km/h	$KE = \frac{1}{2}mv^2 = \frac{1}{2}(7.5 \times 10^7\text{ kg})[(57\text{ km/h})(10^3\text{ m/km})(1\text{h}/3600\text{ s})]^2$ $KE = \boxed{9.4 \times 10^9\text{ J}}$
133. $KE = 7.81 \times 10^4$ J $m = 55.0$ kg	$v = \sqrt{\frac{2\,KE}{m}} = \sqrt{\frac{(2)(7.81 \times 10^4\text{ J})}{55.0\text{ kg}}} = \boxed{53.3\text{ m/s}}$

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134. $v_i = 8.0$ m/s

$v_f = 0$ m/s

$d = 45$ m

$F_k = 0.12$ N

$\theta = 180°$

$$W_{net} = \Delta KE = KE_f - KE_i = \frac{1}{2}mv_f^2 - \frac{1}{2}mv_i^2$$

$$W_{net} = F_{net}d(\cos\theta) = F_k d(\cos\theta)$$

$$\frac{1}{2}m(v_f^2 - v_i^2) = F_k d(\cos\theta)$$

$$m = \frac{2\,F_k d(\cos\theta)}{v_f^2 - v_i^2} = \frac{(2)(0.12 \text{ N})(45 \text{ m})(\cos 180°)}{(0 \text{ m/s})^2 - (8.0 \text{ m/s})^2} = \frac{-(2)(0.12 \text{ N})(45 \text{ m})}{-64 \text{ m}^2/\text{s}^2}$$

$$m = \boxed{0.17 \text{ kg}}$$

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135. $v_i = 2.40 \times 10^2$ km/h

$v_f = 0$ km/h

$a_{net} = 30.8$ m/s^2

$m = 1.30 \times 10^4$ kg

$\theta = 180°$

$$W_{net} = \Delta KE = KE_f - KE_i = \frac{1}{2}mv_f^2 - v_i^2$$

$$W_{net} = F_{net}\,d\,(\cos\theta) = ma_{net}\,d(\cos\theta)$$

$$ma_{net}d(\cos\theta) = \frac{1}{2}m(v_f^2 - v_i^2)$$

$$d = \frac{v_f^2 - v_i^2}{2\,a_{net}\,(\cos\theta)} = \frac{[(0 \text{ km/h})^2 - (2.40 \times 10^2 \text{ km/h})^2]\,(10^3 \text{ m/km})^2(1\text{h}/3600 \text{ s})^2}{(2)(30.8 \text{ m/s}^2)(\cos 180°)}$$

$$d = \frac{(-5.76 \times 10^4 \text{ km}^2/\text{h}^2)(10^3 \text{ m/km})^2\,(1\text{h}/3600 \text{ s})^2}{-(2)(30.8 \text{ m/s}^2)} = \boxed{72.2 \text{ m}}$$

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136. $h = 7.0$ m

$PE_g = 6.6 \times 10^4$ J

$g = 9.81$ m/s^2

$$PE_g = mgh$$

$$m = \frac{PE_g}{gh} = \frac{6.6 \times 10^4 \text{ J}}{(9.81 \text{ m/s}^2)(7.0 \text{ m})}$$

$$m = \boxed{9.6 \times 10^2 \text{ kg}}$$

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137. $k = 1.5 \times 10^4$ N/m

$PE_{elastic} = 120$ J

$$PE_{elastic} = \frac{1}{2}kx^2$$

$$x = \pm\sqrt{\frac{2\,PE_{elastic}}{k}} = \pm\sqrt{\frac{(2)(120 \text{ J})}{1.5 \times 10^4 \text{ N/m}}}$$

Spring is compressed, so negative root is selected.

$$x = \boxed{-0.13 \text{ m} = -13 \text{ cm}}$$

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138. $m = 100.0$ g

$x = 30.0$ cm

$k = 1250$ N/m

$$PE_{elastic} = KE$$

$$\frac{1}{2}kx^2 = \frac{1}{2}mv^2$$

$$v = \sqrt{\frac{kx^2}{m}} = \sqrt{\frac{(1250 \text{ N/m})(30.0 \times 10^{-2} \text{ m})^2}{100.0 \times 10^{-3} \text{ kg}}}$$

$$v = \boxed{33.5 \text{ m/s}}$$

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139. $h = 3.0$ m

$g = 9.81$ m/s^2

$$PE_i = KE_f$$

$$mgh = \frac{1}{2}mv_f^2$$

$$v_f = \sqrt{2gh} = \sqrt{(2)(9.81 \text{ m/s}^2)(3.0 \text{ m})}$$

$$v_f = \boxed{7.7 \text{ m/s}}$$

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140. $W = 1.4 \times 10^{13}$ J

$\Delta t = 8.5$ min

$$P = \frac{W}{\Delta t} = \frac{1.4 \times 10^{13} \text{ J}}{(8.5 \text{ min})(60 \text{ s/min})} = \boxed{2.7 \times 10^{10} \text{ W} = 27 \text{ GW}}$$

Givens — *Solutions*

141. $F = 334$ N

$d = 50.0$ m

$\theta = 0°$

$P = 2100$ W

$W = Fd(\cos\theta)$

$$\Delta t = \frac{W}{P} = \frac{Fd(\cos\theta)}{P} = \frac{(334\ \text{N})(50.0\ \text{m})(\cos 0°)}{2100\ \text{W}} = \boxed{8.0\ \text{s}}$$

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142. $P = (4)(300.0\ \text{kW})$

$\Delta t = 25$ s

$$W = P\,\Delta t = (4)(300.0 \times 10^3\ \text{W})(25\ \text{s}) = \boxed{3.0 \times 10^7\ \text{J}}$$

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143. $F_{applied} = 92$ N

$m = 18$ kg

$\mu_k = 0.35$

$d = 7.6$ m

$g = 9.81\ \text{m/s}^2$

$\theta = 0°$

$KE_i = 0$ J

$W_{net} = \Delta KE = KE_f - KE_i = KE_f$

$W_{net} = F_{net}\, d\,(\cos\theta)$

$F_{net} = F_{applied} - F_k = F_{applied} - \mu_k\, mg$

$KE_f = (F_{applied} - \mu_k\, mg)\, d\,(\cos\theta)$

$= [92\ \text{N} - (0.35)(18\ \text{kg})(9.81\ \text{m/s}^2)](7.6\ \text{m})(\cos 0°)$

$KE_f = (92\ \text{N} - 62\ \text{N})(7.6\ \text{m}) = (3.0 \times 10^1\ \text{N})(7.6\ \text{m})$

$KE_f = \boxed{230\ \text{J}}$

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144. $x = 5.00$ cm

$KE_{car} = 1.09 \times 10^{-4}$ J

Assuming all of the kinetic energy becomes stored elastic potential energy,

$KE_{car} = PE_{elastic} = \frac{1}{2}kx^2$

$$k = \frac{2\,PE_{elastic}}{x^2} = \frac{(2)(1.09 \times 10^4\ \text{J})}{(5.00 \times 10^{-2}\ \text{m})^2}$$

$k = \boxed{8.72 \times 10^6\ \text{N/m}}$

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145. $m = 25.0$ kg

$v = 12.5$ m/s

$g = 9.81\ \text{m/s}^2$

$PE_i = KE_f$

$mgh = \frac{1}{2}mv^2$

$$h = \frac{v^2}{2g} = \frac{(12.5\ \text{m/s})^2}{(2)(9.81\ \text{m/s}^2)} = \boxed{7.96\ \text{m}}$$

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146. $m = 5.0$ kg

$\theta = 25.0°$

$PE_g = 2.4 \times 10^2$ J

$PE_g = mgh = mgd(\sin\theta)$

$$d = \frac{PE_g}{mg\,(\sin\theta)} = \frac{2.4 \times 10^2\ \text{J}}{(5.0\ \text{kg})(9.81\ \text{m/s}^2)(\sin 25.0°)}$$

$d = \boxed{12\ \text{m}}$

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147. $m = 2.00 \times 10^2$ kg

$F_{wind} = 4.00 \times 10^2$ N

$d = 0.90$ km

$v_i = 0$ m/s

$\theta = 0°$

$W_{net} = \Delta KE = KE_f - KE_i = \frac{1}{2}mv_f^2 - \frac{1}{2}mv_i^2$

$W_{net} = F_{net}\, d\,(\cos\theta) = F_{wind}\, d(\cos\theta)$

$\frac{1}{2}mv_f^2 - \frac{1}{2}mv_i^2 = F_{wind}\, d\,(\cos\theta)$

$$v_f = \sqrt{\frac{2F_{wind}\, d\,(\cos\theta)}{m} + v_i^2} = \sqrt{\frac{(2)(4.00 \times 10^2\ \text{N})(0.90 \times 10^3\ \text{m})(\cos 0°)}{2.00 \times 10^2\ \text{kg}} + (0\ \text{m/s})^2}$$

$$v_f = \sqrt{\frac{(2)(4.00 \times 10^2\ \text{N})(9.0 \times 10^2\ \text{m})}{2.00 \times 10^2\ \text{kg}}}$$

$v_f = \boxed{6.0 \times 10^1\ \text{m/s}}$

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Givens	*Solutions*
148. $m = 50.0$ kg $k = 3.4 \times 10^4$ N/m $x = 0.65$ m $h_f = 1.00\text{ m} - 0.65\text{ m} = 0.35$ m	$PE_{g,i} = PE_{elastic,f} + PE_{g,f}$ $mgh_i = \frac{1}{2}kx^2 + mgh_f$ $h_i = h_f + \frac{kx^2}{2\,mg} = 0.35\text{ m} + \frac{(3.4 \times 10^4\text{ N/m})(0.65\text{ m})^2}{(2)(50.0\text{ kg})(9.81\text{ m/s}^2)} = 0.35\text{ m} + 15\text{ m}$ $h_i = \boxed{15\text{ m}}$

Momentum and Collisions

149. $\Delta\mathbf{x} = 274$ m to the north $\Delta t = 8.65$ s $m = 50.0$ kg	$\mathbf{v_{avg}} = \frac{\Delta\mathbf{x}}{\Delta t} = \frac{274\text{ m}}{8.65\text{ s}} = 31.7$ m/s to the north $\mathbf{p} = m\mathbf{v}$ $\mathbf{p_{avg}} = m\mathbf{v_{avg}} = (50.0\text{ kg})(31.7\text{ m/s}) = \boxed{1.58 \times 10^3\text{ kg•m/s to the north}}$
150. $m = 1.46 \times 10^5$ kg $\mathbf{p} = 9.73 \times 10^5$ kg•m/s to the south	$\mathbf{v} = \frac{\mathbf{p}}{m} = \frac{9.73 \times 10^5\text{ kg•m/s}}{1.46 \times 10^5\text{ kg}}$ $\mathbf{v} = \boxed{6.66\text{ m/s to the south}}$
151. $v = 255$ km/s $p = 8.62 \times 10^{36}$ kg•m/s	$m = \frac{p}{v} = \frac{8.62 \times 10^{36}\text{ kg•m/s}}{255 \times 10^3\text{ m/s}} = \boxed{3.38 \times 10^{31}\text{ kg}}$
152. $m = 5.00$ g $\mathbf{v_i} = 255$ m/s to the right $\mathbf{v_f} = 0$ m/s $\Delta t = 1.45$ s	$\Delta\mathbf{p} = m\mathbf{v_f} - m\mathbf{v_i} = \mathbf{F}\Delta t$ $F = \frac{mv_f - mv_i}{\Delta t} = \frac{(5.00 \times 10^{-3}\text{ kg})(0\text{ m/s}) - (5.00 \times 10^{-3}\text{ kg})(255\text{ m/s})}{1.45\text{ s}} = -0.879$ N $\mathbf{F} = \boxed{0.879\text{ N to the left}}$
153. $m = 0.17$ kg $\Delta v = -9.0$ m/s $g = 9.81$ m/s^2 $\mu_k = 0.050$	$F\Delta t = \Delta p = m\Delta v$ $F = F_k = -mg\mu_k$ $\Delta t = \frac{m\Delta v}{-mg\mu_k} = \frac{\Delta v}{-g\mu_k} = \frac{-9.0\text{ m/s}}{-(9.81\text{ m/s}^2)(0.050)}$ $\Delta t = \boxed{18\text{ s}}$
154. $\mathbf{v_i} = 382$ km/h to the right $\mathbf{v_f} = 0$ km/h $m_c = 705$ kg $m_d = 65$ kg $\Delta t = 12.0$ s	$\mathbf{F} = \frac{\Delta\mathbf{p}}{\Delta t} = \frac{(m_c + m_d)\mathbf{v_f} - (m_c + m_d)\mathbf{v_i}}{\Delta t}$ $\mathbf{F} = \frac{[(705\text{ kg} + 65\text{ kg})(0\text{ km/h}) - (705\text{ kg} + 65\text{ kg})(382\text{ km/h})](10^3\text{ m//km})(1\text{ h}/3600\text{ s})}{12.0\text{ s}}$ $\mathbf{F} = \frac{-(7.70 \times 10^2\text{ kg})(382\text{ km/h})(10^3\text{ m/km})(1\text{ h}/3600\text{ s})}{12.0\text{ s}} = -6.81 \times 10^3$ N $\mathbf{F} = \boxed{6.81 \times 10^3\text{ N to the left}}$

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Givens	Solutions
155. $\mathbf{v_i}$ = 382 km/h to the right $\mathbf{v_f}$ = 0 km/h Δt = 12.0 s	$\Delta\mathbf{x} = \frac{1}{2}(\mathbf{v_i} + \mathbf{v_f})\Delta t = \frac{1}{2}(382\text{ km/h} + 0\text{ km/h})(10^3\text{ m/km})(1\text{ h}/3600\text{ s})(12.0\text{ s})$ $\Delta\mathbf{x} = \boxed{637\text{ m to the right}}$
156. $m_1 = 50.0$ g $\mathbf{v_{1,i}}$ = 0 m/s $\mathbf{v_{1,f}}$ = 400.0 m/s forward $m_2 = 3.00$ kg $\mathbf{v_{2,i}}$ = 0 m/s	Because the initial velocities for both rifle and projectile are zero, the momentum conservation equation takes the following form: $m_1\mathbf{v_{1,f}} + m_2\mathbf{v_{2,f}} = 0$ $\mathbf{v_{2,f}} = \frac{-m_1\mathbf{v_{1,f}}}{m_2} = \frac{-(50.0 \times 10^{-3}\text{ kg})(400.0\text{ m/s})}{3.00\text{ kg}} = -6.67\text{ m/s}$ $\mathbf{v_{2,f}} = \boxed{6.67\text{ m/s backward}}$
157. $\mathbf{v_{1,i}}$ = 0 cm/s $\mathbf{v_{1,f}}$ = 1.2 cm/s forward = +1.2 cm/s $\mathbf{v_{2,i}}$ = 0 cm/s $\mathbf{v_{2,f}}$ = 0.40 cm/s backward = −0.40 cm/s $m_1 = 2.5$ g	$m_1\mathbf{v_{1,f}} + m_2\mathbf{v_{2,f}} = 0$ $m_2 = \frac{-m_1\mathbf{v_{1,f}}}{\mathbf{v_{2,f}}} = \frac{-(2.5\text{ g})(1.2\text{ cm/s})}{-0.40\text{ cm/s}}$ $m_2 = \boxed{7.5\text{ g}}$
158. $m_s = 25.0$ kg $m_c = 42.0$ kg $v_{1,i} = 3.50$ m/s $v_{2,i} = 0$ m/s $v_f = 2.90$ m/s	m_1 = mass of child and sled = $m_s + m_c = 25.0\text{ kg} + 42.0\text{ kg} = 67.0\text{ kg}$ $m_1v_{1,i} + m_2v_{2,i} = (m_1 + m_2)v_f$ $m_2 = \frac{m_1v_{1,i} - m_1v_f}{v_f - v_{2,i}} = \frac{(67.0\text{ kg})(3.50\text{ m/s}) - (67.0\text{ kg})(2.90\text{ m/s})}{2.90\text{ m/s} - 0\text{ m/s}}$ $m_2 = \frac{234\text{ kg}\bullet\text{m/s} + 938\text{ kg}\bullet\text{m/s}}{2.90\text{ m/s}} = \frac{40\text{ kg}\bullet\text{m/s}}{2.90\text{ m/s}} = \boxed{14\text{ kg}}$
159. $m_1 = 8500$ kg $\mathbf{v_{1,i}}$ = 4.5 m/s to the right = +4.5 m/s $m_2 = 9800$ kg $\mathbf{v_{2,i}}$ = 3.9 m/s to the left = −3.9 m/s	$\mathbf{v_f} = \frac{m_1\mathbf{v_{1,i}} + m_2\mathbf{v_{2,i}}}{m_1 + m_2}$ $\mathbf{v_f} = \frac{(8500\text{ kg})(4.5\text{ m/s}) + (9800\text{ kg})(-3.9\text{ m/s})}{8500\text{ kg} + 9800\text{ kg}} = \frac{3.8 \times 10^4\text{ kg•m/s} - 3.8 \times 10^4\text{ kg•m/s}}{1.83 \times 10^4\text{ kg}}$ $\mathbf{v_f} = \boxed{0.0\text{ m/s}}$
160. $m_1 = 8500$ kg $v_{1,i} = 4.5$ m/s $m_2 = 9800$ kg $v_{2,i} = -3.9$ m/s $v_f = 0$ m/s	$KE_i = \frac{1}{2}m_1v_{1,i}^2 + \frac{1}{2}m_2v_{2,i}^2 = \frac{1}{2}(8500\text{ kg})(4.5\text{ m/s})^2 + \frac{1}{2}(9800\text{ kg})(-3.9\text{ m/s})^2$ $KE_i = 8.6 \times 10^4\text{ J} + 7.5 \times 10^4\text{ J} = 16.1 \times 10^4\text{ J} = 1.61 \times 10^5\text{ J}$ $KE_f = \frac{1}{2}(m_1 + m_2)v_f^2 = \frac{1}{2}(8500\text{ kg} + 9800\text{ kg})(0\text{ m/s})^2 = 0\text{ J}$ $\Delta KE = KE_f - KE_i = 0\text{ J} - 1.61 \times 10^5\text{ J} = \boxed{-1.61 \times 10^5\text{ J}}$

Givens	Solutions
161. $m_1 = 55$ g $v_{1,i} = 1.5$ m/s $m_2 = 55$ g $v_{2,i} = 0$ m/s	$v_f = \frac{m_1 v_{1,i} + m_2 v_{2,i}}{m_1 + m_2} = \frac{(55\text{ g})(1.5\text{ m/s}) + (55\text{ g})(0\text{ m/s})}{55\text{ g} + 55\text{ g}} = \frac{(55\text{ g})(1.5\text{ m/s})}{1.10 \times 10^2\text{ g}}$ $v_f = 0.75$ m/s percent decrease of $KE = \frac{\Delta KE}{KE_i} \times 100 = \frac{KE_f - KE_i}{KE_i} \times 100 = \left(\frac{KE_f}{KE_i} - 1\right) \times 100$ $KE_i = \frac{1}{2}m_1 v_{1,i}^2 + \frac{1}{2}m_2 v_{2,i}^2 = \frac{1}{2}(55 \times 10^{-3}\text{ kg})(1.5\text{ m/s})^2 + \frac{1}{2}(55 \times 10^{-3}\text{ kg})(0\text{ m/s})^2$ $KE_i = 6.2 \times 10^{-2}\text{ J} + 0\text{ J} = 6.2 \times 10^{-2}\text{ J}$ $KE_f = \frac{1}{2}(m_1 + m_2)v_f^2 = \frac{1}{2}(55\text{ g} + 55\text{ g})(10^{-3}\text{ kg/g})(0.75\text{ m/s})^3$ $KE_f = 3.1 \times 10^{-2}$ J percent decrease of **KE** $= \left[\left(\frac{3.1 \times 10^{-2}\text{ J}}{6.2 \times 10^{-2}\text{ J}}\right) - 1\right] \times 100 = (0.50 - 1) \times 100 = (-0.50) \times 100$ percent decrease of **KE** $= \boxed{-5.0 \times 10^1 \text{ percent}}$
162 $m_1 = m_2 = 45$ g $v_{2,i} = 0$ m/s $v_{1,f} = 0$ m/s $v_{2,f} = 3.0$ m/s	Momentum conservation $m_1 v_{1,i} + m_2 v_{2,i} = m_1 v_{1,f} + m_2 v_{2,f}$ $v_{1,i} = v_{1,f} + v_{2,f} - v_{2,i} = 0\text{ m/s} + 3.0\text{ m/s} - 0\text{ m/s}$ $v_{1,i} = \boxed{3.0\text{ m/s}}$ Conservation of kinetic energy (check) $\frac{1}{2}m_1 v_{1,i}^2 + \frac{1}{2}m_2 v_{2,i}^2 = \frac{1}{2}m_1 v_{1,f}^2 + \frac{1}{2}m_2 v_{2,f}^2$ $v_{1,i}^2 + v_{2,i}^2 = v_{1,f}^2 + v_{2,f}^2$ $(3.0\text{ m/s})^2 + (0\text{ m/s})^2 = (0\text{ m/s})^2 + (3.0\text{ m/s})^2$ $9.0\text{ m}^2/\text{s}^2 = 9.0\text{ m}^2/\text{s}^2$
163. $m = 5.00 \times 10^2$ kg **p** $= 8.22 \times 10^3$ kg•m/s to the west	$\mathbf{v} = \frac{\mathbf{p}}{m} = \frac{8.22 \times 10^3\text{ kg•m/s}}{5.00 \times 10^2\text{ kg}}$ $\mathbf{v} = \boxed{16.4\text{ m/s to the west}}$

Givens	Solutions

164. $m_1 = 3.0 \times 10^7$ kg

$m_2 = 2.5 \times 10^7$ kg

$\mathbf{v_{2,i}} = 4.0$ km/h to the north $= +4.0$ km/h

$\mathbf{v_{1,f}} = 3.1$ km/h to the north $= +3.1$ km/h

$\mathbf{v_{2,f}} = 6.9$ km/h to the south $= -6.9$ km/h

Momentum conservation

$$m_1\mathbf{v_{1,i}} + m_2\mathbf{v_{2,i}} = m_1\mathbf{v_{1,f}} + m_2\mathbf{v_{2,f}}$$

$$\mathbf{v_{1,i}} = \frac{m_1\mathbf{v_{1,f}} + m_2\mathbf{v_{2,f}} - m_2\mathbf{v_{2,i}}}{m_1}$$

$$\frac{(3.0 \times 10^7 \text{ kg})(3.1 \text{ km/h}) + (2.5 \times 10^7 \text{ kg})(-6.9 \text{ km/h}) - (2.5 \times 10^7 \text{ kg})(4.0 \text{ km/h})}{3.0 \times 10^7 \text{ kg}}$$

$$\mathbf{v_{1,i}} = \frac{9.3 \times 10^7 \text{ kg•km/h} - 1.7 \times 10^8 \text{ kg•km/h} - 1.0 \times 10^8 \text{ kg•km/h}}{3.0 \times 10^7 \text{ kg}}$$

$$\mathbf{v_{1,i}} = \frac{-1.8 \times 10^8 \text{ kg•km/h}}{3.0 \times 10^7 \text{ kg}} = -6.0 \text{ km/h}$$

$$\mathbf{v_{1,i}} = \boxed{6.0 \text{ km/h to the south}}$$

Conservation of kinetic energy (check)

$$\tfrac{1}{2}m_1v_{1,i}^2 + \tfrac{1}{2}m_2v_{2,i}^2 = \tfrac{1}{2}m_1v_{1,f}^2 + \tfrac{1}{2}m_2v_{2,f}^2$$

$$\tfrac{1}{2}(3.0 \times 10^7 \text{ kg})[(-6.0 \times 10^3 \text{ m/h})(1 \text{ h}/3600 \text{ s})]^2 + \tfrac{1}{2}(2.5 \times 10^7 \text{ kg})[(4.0 \times 10^3 \text{ m/h})(1 \text{ h}/3600 \text{ s})]^2$$

$$= \tfrac{1}{2}(3.0 \times 10^7 \text{ kg})[(3.1 \times 10^3 \text{ m/h})(1 \text{ h}/3600 \text{ s})]^2 + \tfrac{1}{2}(2.7 \times 10^7 \text{ kg})[(-6.9 \times 10^3 \text{ m/h})(1 \text{ h}/3600 \text{ s})]^2$$

$$4.2 \times 10^7 \text{ J} + 1.5 \times 10^7 \text{ J} = 1.1 \times 10^7 \text{ J} + 4.6 \times 10^7 \text{ J}$$

$$5.7 \times 10^7 \text{ J} = 5.7 \times 10^7 \text{ J}$$

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165. $m = 7.10 \times 10^5$ kg

$v = 270$ km/h

$$p = mv = (7.10 \times 10^5 \text{ kg})(270 \text{ km/h})(10^3 \text{ m/km})(1 \text{ h}/3600 \text{ s})$$

$$p = \boxed{5.33 \times 10^7 \text{ kg•m/s}}$$

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166. $v = 50.0$ km/h

$p = 0.278$ kg•m/s

$$m = \frac{p}{v} = \frac{0.278 \text{ kg•m/s}}{(50.0 \text{ km/h})(10^3 \text{ m/km})(1 \text{ h}/3600 \text{ s})}$$

$$m = \boxed{2.00 \times 10^{-2} \text{ kg} = 20.0 \text{ g}}$$

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167. $F = 75$ N

$m = 55$ kg

$\Delta t = 7.5$ s

$v_i = 0$ m/s

$$\Delta p = mv_f - mv_i = F\Delta t$$

$$v_f = \frac{F\Delta t + mv_i}{m} = \frac{(75 \text{ N})(7.5 \text{ s}) + (55 \text{ kg})(0 \text{ m/s})}{55 \text{ kg}}$$

$$v_f = \boxed{1.0 \times 10^1 \text{ m/s}}$$

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168. $m = 60.0$ g

$F = -1.5$ N

$\Delta t = 0.25$ s

$v_f = 0$ m/s

$$\Delta p = mv_f - mv_i = F\Delta t$$

$$v_i = \frac{mv_f - F\Delta t}{m} = \frac{(60.0 \times 10^{-3} \text{ kg})(0 \text{ m/s}) - (-1.5 \text{ N})(0.25 \text{ s})}{60.0 \times 10^{-3} \text{ kg}} = \frac{(1.5 \text{ N})(0.25 \text{ s})}{60.0 \times 10^{-3} \text{ kg}}$$

$$v_i = \boxed{6.2 \text{ m/s}}$$

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169. $m = 1.1 \times 10^3$ kg

$\mathbf{v_f} = 9.7$ m/s to the east

$\mathbf{v_i} = 0$ m/s

$\Delta t = 19$ s

$$\mathbf{F} = \frac{\Delta \mathbf{p}}{\Delta t} = \frac{m\mathbf{v_f} - m\mathbf{v_i}}{\Delta t}$$

$$\mathbf{F} = \frac{(1.1 \times 10^3 \text{ kg})(9.7 \text{ m/s}) - (1.1 \times 10^3 \text{ kg})(0 \text{ m/s})}{19 \text{ s}} = 560 \text{ N}$$

$$\mathbf{F} = \boxed{560 \text{ N to the east}}$$

Givens	Solutions
170. $m = 12.0$ kg	$F = F_{applied}(\cos\theta) - F_{friction}$
$F_{applied} = 15.0$ N	$\Delta t = \dfrac{\Delta p}{F} = \dfrac{mv_f - mv_i}{F_{applied}(\cos\theta) - F_{friction}} = \dfrac{(12.0\text{ kg})(4.50\text{ m/s}) - (12.0\text{ kg})(0\text{ m/s})}{(15.0\text{ N})(\cos 20.0°) - 11.0\text{ N}}$
$\theta = 20.0°$	
$F_{friction} = 11.0$ N	$\Delta t = \dfrac{54.0\text{ kg}\bullet\text{m/s} - 0\text{ kg}\bullet\text{m/s}}{14.1\text{ N} - 11.0\text{ N}} = \dfrac{54.0\text{ kg}\bullet\text{m/s}}{3.1\text{ N}}$
$v_i = 0$ m/s	
$v_f = 4.50$ m/s	$\Delta t = \boxed{17\text{ s}}$
171. $v_i = 7.82 \times 10^3$ m/s	$\mathbf{F} = \dfrac{\Delta\mathbf{p}}{\Delta t} = \dfrac{mv_f - mv_i}{\Delta t}$
$v_f = 0$ m/s	
$m = 42$ g	$F = \dfrac{(42 \times 10^{-3}\text{ kg})(0\text{ m/s}) - (42 \times 10^{-3}\text{ kg})(7.82 \times 10^3\text{ m/s})}{1.0 \times 10^{-6}\text{ s}}$
$\Delta t = 1.0 \times 10^{-6}$ s	$F = \dfrac{-(42 \times 10^{-3}\text{ kg})(7.82 \times 10^3\text{ m/s})}{1.0 \times 10^{-6}\text{ s}}$
	$F = \boxed{-3.3 \times 10^8\text{ N}}$
172. $m = 455$ kg	$\Delta\mathbf{p} = \mathbf{F}\Delta t$
$\Delta t = 12.2$ s	$\mathbf{F} = \mathbf{F_k} = -mg\mu_k$
$\mu_k = 0.071$	$\Delta\mathbf{p} = -mg\mu_k\Delta t = -(455\text{ kg})(9.81\text{ m/s}^2)(0.071)(12.2\text{ s}) = -3.9 \times 10^3$ kg•ms
$g = 9.81$ m/s^2	$\Delta\mathbf{p} = \boxed{3.9 \times 10^3\text{ kg•ms opposite the polar bear's motion}}$
$v_f = 0$ m/s	
173. $m = 455$ kg	$v_i = \dfrac{mv_f - \Delta p}{m} = \dfrac{(455\text{ kg})(0\text{ m/s}) - (-3.9 \times 10^3\text{ kg•ms})}{455\text{ kg}}$
$\Delta t = 12.2$ s	
$\mu_k = 0.071$	$v_i = \dfrac{3.9 \times 10^3\text{ kg•ms}}{455\text{ kg}} = 8.6$ m/s
$g = 9.81$ m/s^2	
$v_f = 0$ m/s	$\Delta x = \frac{1}{2}(v_i + v_f)\Delta t = \frac{1}{2}(8.6\text{ m/s} + 0\text{ m/s})(12.2\text{ s})$
	$\Delta x = \boxed{52\text{ m}}$

Givens | *Solutions*

174. $m = 2.30 \times 10^3$ kg

$v_i = 22.2$ m/s

$v_f = 0$ m/s

$F = -1.26 \times 10^4$ N

$$\Delta t = \frac{\Delta p}{F} = \frac{mv_f - mv_i}{F}$$

$$\Delta t = \frac{(2.30 \times 10^3 \text{ kg})(0 \text{ m/s}) - (2.30 \times 10^3 \text{ kg})(22.2 \text{ m/s})}{-1.26 \times 10^4 \text{ N}} = \frac{-5.11 \times 10^4 \text{ kg•m/s}}{-1.26 \times 10^4 \text{ N}}$$

$$\Delta t = \boxed{4.06 \text{ s}}$$

175. $\mathbf{v_{1,i}} = 0$ m/s

$\mathbf{v_{2,i}} = 5.4$ m/s to the north

$\mathbf{v_{1,f}} = 1.5$ m/s to the north

$\mathbf{v_{2,f}} = 1.5$ m/s to the north

$m_1 = 63$ kg

$$m_1\mathbf{v_{1,i}} + m_2\mathbf{v_{2,i}} = m_1\mathbf{v_{1,f}} + m_2\mathbf{v_{2,f}}$$

$$m_2 = \frac{m_1\mathbf{v_{1,f}} - m_1\mathbf{v_{1,i}}}{\mathbf{v_{2,i}} - \mathbf{v_{2,f}}} = \frac{(63 \text{ kg})(1.5 \text{ m/s}) - (63 \text{ kg})(0 \text{ m/s})}{5.4 \text{ m/s} - 1.5 \text{ m/s}} = \frac{(63 \text{ kg})(1.5 \text{ m/s})}{3.9 \text{ m/s}}$$

$$m_2 = \boxed{24 \text{ kg}}$$

176. $m_i = 1.36 \times 10^4$ kg

$m_2 = 8.4 \times 10^3$ kg

$v_{2,i} = 0$ m/s

$v_{1,f} = v_{2,f} = 1.3$ m/s

$$m_1v_{1,i} + m_2v_{2,i} = m_1v_{1,f} + m_2v_{2,f}$$

$$v_{1,i} = \frac{m_1v_{1,f} + m_2v_{2,f} - m_2v_{2,i}}{m_1}$$

$$v_{1,i} = \frac{(1.36 \times 10^4 \text{ kg})(1.3 \text{ m/s}) + (8.4 \times 10^3 \text{ kg})(1.3 \text{ m/s}) - (8.4 \times 10^3 \text{ kg})(0 \text{ m/s})}{1.36 \times 10^4 \text{ kg}}$$

$$v_{1,i} = \frac{1.8 \times 10^4 \text{ kg•m/s} + 1.1 \times 10^4 \text{ kg•m/s}}{1.36 \times 10^4 \text{ kg}} = \frac{2.9 \times 10^4 \text{ kg•m/s}}{1.36 \times 10^4 \text{ kg}}$$

$$v_{1,i} = \boxed{2.1 \text{ m/s}}$$

177. $m_i = 1292$ kg

$\mathbf{v_i} = 88.0$ km/h to the east

$m_f = 1255$ kg

$$m_i\mathbf{v_i} = m_f\mathbf{v_f}$$

$$\mathbf{v_f} = \frac{m_i\mathbf{v_i}}{m_f} = \frac{(1292 \text{ kg})(88.0 \text{ km/h})}{1255 \text{ kg}}$$

$$\mathbf{v_f} = \boxed{90.6 \text{ km/h to the east}}$$

178. $m_1 = 68$ kg

$m_2 = 68$ kg

$\mathbf{v_{2,i}} = 0$ m/s

$\mathbf{v_{1,f}} = 0.85$ m/s to the west $= -0.85$ m/s

$\mathbf{v_{2,f}} = 0.85$ m/s to the west $= -0.85$ m/s

$$m_1\mathbf{v_{1,i}} + m_2\mathbf{v_{2,i}} = m_1\mathbf{v_{1,f}} + m_2\mathbf{v_{2,f}}$$

$$\mathbf{v_{1,i}} = \frac{m_1\mathbf{v_{1,f}} + m_2\mathbf{v_{2,f}} - m_2\mathbf{v_{2,i}}}{m_i} = \frac{(68 \text{ kg})(-0.85 \text{ m/s}) + (68 \text{ kg})(-0.85 \text{ m/s}) - (68 \text{ kg})(0 \text{ m/s})}{68 \text{ kg}}$$

$$\mathbf{v_{1,i}} = -0.85 \text{ m/s} + (-0.85 \text{ m/s}) = -1.7 \text{ m/s}$$

$$\mathbf{v_{1,i}} = \boxed{1.7 \text{ m/s to the west}}$$

Givens	Solutions

179. $m_1 = 1400$ kg

$\mathbf{v_{1,i}} = 45$ km/h to the north

$m_2 = 2500$ kg

$\mathbf{v_{2,i}} = 33$ km/h to the east

$$\mathbf{v_f} = \frac{m_1\mathbf{v_{1,i}} + m_2\mathbf{v_{2,i}}}{m_1 + m_2}$$

The component of $\mathbf{v_f}$ in the x-direction is given by

$$v_{f,x} = \frac{m_2 v_{2,i}}{m_1 + m_2} = \frac{(2500 \text{ kg})(33 \text{ km/h})}{1400 \text{ kg} + 2500 \text{ kg}} = \frac{(2500 \text{ kg})(33 \text{ km/h})}{3900 \text{ kg}}$$

$v_{f,x} = 21$ km/h

The component of $\mathbf{v_f}$ in the y-direction is given by

$$v_{f,y} = \frac{m_1 v_{1,i}}{m_1 + m_2} = \frac{(1400 \text{ kg})(45 \text{ km/h})}{1400 \text{ kg} + 2500 \text{ kg}} = \frac{(1400 \text{ kg})(45 \text{ km/h})}{3900 \text{ kg}}$$

$v_{f,y} = 16$ km/h

$$v_f = \sqrt{v_{f,x}^2 + v_{f,y}^2} = \sqrt{(21 \text{ km/h})^2 + (16 \text{ km/h})^2}$$

$$v_f = \sqrt{440 \text{ km}^2/\text{h}^2 + 260 \text{ km}^2/\text{h}^2} = \sqrt{7.0 \times 10^2 \text{ km}^2/\text{h}^2}$$

$v_f = 26$ km/h

$$\theta = \tan^{-1}\left(\frac{v_{f,y}}{v_{f,x}}\right) = \tan^{-1}\left(\frac{16 \text{ km/h}}{21 \text{ km/h}}\right) = 37°$$

$\mathbf{v_f} =$ **26 km/h at 37° north of east**

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180. $m_1 = 4.5$ kg

$v_{1,i} = 0$ m/s

$m_2 = 1.3$ kg

$v_f = 0.83$ m/s

$$v_{2,i} = \frac{(m_1 + m_2)v_f - m_1 v_{1,i}}{m_2} = \frac{(4.5 \text{ kg} + 1.3 \text{ kg})(0.83 \text{ m/s}) - (4.5 \text{ kg})(0 \text{ m/s})}{1.3 \text{ kg}}$$

$$v_{2,i} = \frac{(5.8 \text{ kg})(0.83 \text{ m/s})}{1.3 \text{ kg}} = 3.7 \text{ m/s}$$

$$KE_i = \tfrac{1}{2}m_1 v_{1,i}^2 + \tfrac{1}{2}m_2 v_{2,i}^2 = \tfrac{1}{2}(4.5 \text{ kg})(0 \text{ m/s})^2 + \tfrac{1}{2}(1.3 \text{ kg})(3.7 \text{ m/s})^2$$

$KE_i = 0 \text{ J} + 8.9 \text{ J} = 8.9$ J

$$KE_f = \tfrac{1}{2}(m_1 + m_2)v_f^2 = \tfrac{1}{2}(4.5 \text{ kg} + 1.3 \text{ kg})(0.83 \text{ m/s})^2 = \tfrac{1}{2}(5.8 \text{ kg})(0.83 \text{ m/s})^2$$

$KE_f = 2.0$ J

$\Delta KE = KE_f - KE_i = 2.0 \text{ J} - 8.9 \text{ J} =$ **−6.9 J**

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181. $m_1 = 0.650$ kg

$\mathbf{v_{1,i}} = 15.0$ m/s to the right $= +15.0$ m/s

$m_2 = 0.950$ kg

$\mathbf{v_{2,i}} = 13.5$ m/s to the left $= -13.5$ m/s

$$\mathbf{v_f} = \frac{m_1\mathbf{v_{1,i}} + m_2\mathbf{v_{2,i}}}{m_1 + m_2} = \frac{(0.650 \text{ kg})(15.0 \text{ m/s}) + (0.950 \text{ kg})(-13.5 \text{ m/s})}{0.650 \text{ kg} + 0.950 \text{ kg}}$$

$$\mathbf{v_f} = \frac{9.75 \text{ kg•m/s} - 12.8 \text{ kg•m/s}}{1.600 \text{ kg}} = \frac{-3.0 \text{ kg•m/s}}{1.600 \text{ kg}} = -1.91 \text{ m/s}$$

$\mathbf{v_f} = 1.91$ m/s to the left

$$KE_i = \tfrac{1}{2}m_1 v_{1,i}^2 + \tfrac{1}{2}m_2 v_{2,i}^2 = \tfrac{1}{2}(0.650 \text{ kg})(15.0 \text{ m/s})^2 + \tfrac{1}{2}(0.950 \text{ kg})(-13.5 \text{ m/s})^2$$

$KE_i = 73.1 \text{ J} + 86.6 \text{ J} = 159.7$ J

$$KE_f = \tfrac{1}{2}(m_1 + m_2)v_f^2 = \tfrac{1}{2}(0.650 \text{ kg} + 0.950 \text{ kg})(1.91 \text{ m/s})^2 = \tfrac{1}{2}(1.600 \text{ kg})(1.91 \text{ m/s})^2$$

$KE_f = 2.92$ J

$\Delta KE = KE_f - KE_i = 2.92 \text{ J} - 159.7 \text{ J} =$ **-1.57×10^2 J**

Givens	*Solutions*
182. $m_1 = 10.0$ kg $m_2 = 2.5$ kg $v_{1,i} = 6.0$ m/s $v_{2,i} = -3.0$ m/s	$v_f = \frac{m_1 v_{1,i} + m_2 v_{2,i}}{m_1 + m_2} = \frac{(10.0 \text{ kg})(6.0 \text{ m/s}) + (2.5 \text{ kg})(-3.0 \text{ m/s})}{10.0 \text{ kg} + 2.5 \text{ kg}}$ $v_f = \frac{6.0 \times 10^1 \text{ kg•m/s} - 7.5 \text{ kg•m/s}}{12.5 \text{ kg}} = \frac{52 \text{ kg•m/s}}{12.5 \text{ kg}} = \boxed{4.2 \text{ m/s}}$
183. $\mathbf{v_{1,i}} = 6.00$ m/s to the right $= +6.00$ m/s $\mathbf{v_{2,i}} = 0$ m/s $\mathbf{v_{1,f}} = 4.90$ m/s to the left $= -4.90$ m/s $\mathbf{v_{2,f}} = 1.09$ m/s to the right $= +1.09$ m/s $m_2 = 1.25$ kg	Momentum conservation $m_1\mathbf{v_{1,i}} + m_2\mathbf{v_{2,i}} = m_1\mathbf{v_{1,f}} + m_2\mathbf{v_{2,f}}$ $m_1 = \frac{m_2\mathbf{v_{2,f}} - m_2\mathbf{v_{2,i}}}{\mathbf{v_{1,i}} - \mathbf{v_{1,f}}} = \frac{(1.25 \text{ kg})(1.09 \text{ m/s}) - (1.25 \text{ kg})(0 \text{ m/s})}{6.00 \text{ m/s} - (-4.90 \text{ m/s})} = \frac{1.36 \text{ kg•m/s}}{10.90 \text{ m/s}}$ $m_1 = \boxed{0.125 \text{ kg}}$ Conservation of kinetic energy (check) $\frac{1}{2}m_1 v_{1,i}^2 + \frac{1}{2}m_2 v_{2,i}^2 = \frac{1}{2}m_1 v_{1,f}^2 + \frac{1}{2}m_2 v_{2,f}^2$ $\frac{1}{2}(0.125 \text{ kg})(6.00 \text{ m/s})^2 + \frac{1}{2}(1.25 \text{ kg})(0 \text{ m/s})^2 = \frac{1}{2}(0.125 \text{ kg})(-4.90 \text{ m/s})^2$ $+ \frac{1}{2}(1.25 \text{ kg})(1.09 \text{ m/s})^2$ $2.25 \text{ J} + 0 \text{ J} = 1.50 \text{ J} + 0.74 \text{ J}$ $2.25 \text{ J} = 2.24 \text{ J}$ The slight difference arises from rounding.
184. $m_1 = 2150$ kg $\mathbf{v_{1,i}} = 10.0$ m/s to the east $m_2 = 3250$ kg $\mathbf{v_f} = 5.22$ m/s to the east	$\mathbf{v_{2,i}} = \frac{(m_1 + m_2)\mathbf{v_f} - m_1\mathbf{v_{1,i}}}{m_2}$ $\mathbf{v_{2,i}} = \frac{(2150 \text{ kg} + 3250 \text{ kg})(5.22 \text{ m/s}) - (2150 \text{ kg})(10.0 \text{ m/s})}{3250 \text{ kg}}$ $\mathbf{v_{2,i}} = \frac{(5.40 \times 10^3 \text{ kg})(5.22 \text{ m/s}) - (2150 \text{ kg})(10.0 \text{ m/s})}{3250 \text{ kg}}$ $\mathbf{v_{2,i}} = \frac{2.82 \times 10^4 \text{ kg•m/s} - 2.15 \times 10^4 \text{ kg•m/s}}{3250 \text{ kg}} = \frac{6700 \text{ kg•m/s}}{3250 \text{ kg}}$ $\mathbf{v_{2,i}} = \boxed{2.1 \text{ m/s to the east}}$
185. $m_1 = 2150$ kg $\mathbf{v_{1,i}} = 10.0$ m/s to the east $m_2 = 3250$ kg $\mathbf{v_f} = 5.22$ m/s to the east $\mathbf{v_{2,i}} = 2.1$ m/s to the east	$\Delta KE = KE_f - KE_i$ $KE_i = \frac{1}{2}m_1 v_{1,i}^2 + \frac{1}{2}m_2 v_{2,i}^2 = \frac{1}{2}(2150 \text{ kg})(10.0 \text{ m/s})^2 + \frac{1}{2}(3250 \text{ kg})(2.1 \text{ m/s})^2$ $KE_i = 1.08 \times 10^5 \text{ J} + 7.2 \times 10^3 \text{ J} = 1.15 \times 10^5 \text{ J}$ $KE_f = \frac{1}{2}(m_1 + m_2)v_f^2 = \frac{1}{2}(2150 \text{ kg} + 3250 \text{ kg})(5.22 \text{ m/s})^2$ $KE_f = \frac{1}{2}(5.40 \times 10^3 \text{ kg})(5.22 \text{ m/s})^2 = 7.36 \times 10^4 \text{ J}$ $\Delta KE = KE_f - KE_i = 7.36 \times 10^4 \text{ J} - 1.15 \times 10^5 \text{ J} = -4.1 \times 10^4 \text{ J}$ The kinetic energy decreases by $\boxed{4.1 \times 10^4 \text{ J}}$.

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186. $m_1 = 15.0$ g

$\mathbf{v_{1,i}} = 20.0$ cm/s to the right $= +20.0$ cm/s

$m_2 = 20.0$ g

$\mathbf{v_{2,i}} = 30.0$ cm/s to the left $= -30.0$ cm/s

$\mathbf{v_{1,f}} = 37.1$ cm/s to the left $= -37.1$ cm/s

$$\mathbf{v_{2,f}} = \frac{m_1\mathbf{v_{1,i}} + m_2\mathbf{v_{2,i}} - m_1\mathbf{v_{1,f}}}{m_2}$$

$$\mathbf{v_{2,f}} = \frac{(15.0\text{ g})(20.0\text{ cm/s}) + (20.0\text{ g})(-30.0\text{ cm/s}) - (15.0\text{ g})(-37.1\text{ cm/s})}{20.0\text{ g}}$$

$$\mathbf{v_{2,f}} = \frac{3.00 \times 10^2\text{ g}\bullet\text{cm/s} - 6.00 \times 10^2\text{ g}\bullet\text{cm/s} + 5.56 \times 10^2\text{ g}\bullet\text{cm/s}}{20.0\text{ g}}$$

$$\mathbf{v_{2,f}} = \frac{256\text{ g}\bullet\text{cm/s}}{20.0\text{ g}} = \boxed{12.8\text{ cm/s to the right}}$$

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187. $\mathbf{v_{1,i}} = 5.0$ m/s to the right $= +5.0$ m/s

$\mathbf{v_{2,i}} = 7.00$ m/s to the left $= -7.00$ m/s

$\mathbf{v_f} = 6.25$ m/s to the left $= -6.25$ m/s

$m_2 = 150.0$ kg

$$m_1 = \frac{m_2\mathbf{v_{2,i}} - m_2\mathbf{v_f}}{\mathbf{v_f} - \mathbf{v_{1,i}}} = \frac{(150.0\text{ kg})(-7.00\text{ m/s}) - (150.0\text{ kg})(-6.25\text{ m/s})}{-6.25\text{ m/s} - 5.0\text{ m/s}}$$

$$m_1 = \frac{-1050\text{ kg}\bullet\text{m/s} + 938\text{ kg}\bullet\text{m/s}}{-11.2\text{ m/s}} = \frac{-110\text{ kg}\bullet\text{m/s}}{-11.2\text{ m/s}}$$

$$m_1 = \boxed{9.8\text{ kg}}$$

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188. $m_1 = 6.5 \times 10^{12}$ kg

$v_1 = 420$ m/s

$m_2 = 1.50 \times 10^{13}$ kg

$v_2 = 250$ m/s

Conservation of Momentum gives:

$$m_1v_{1i} + m_2v_{2i} = (m_1 + m_2)v_f$$

$$v_f = \frac{m_1v_{1i} + m_2v_{2i}}{m_1 + m_2}$$

The change in Kinetic Energy is:

$$\Delta KE = KE_f - KE_i = \frac{1}{2}(m_1 + m_2)v_f^2 - \left(\frac{1}{2}m_1v_{1i}^2 + \frac{1}{2}m_2v_{2f}^2\right)$$

$$2\Delta KE = (m_1 + m_2)\left(\frac{m_1v_{1i} + m_2v_{2i}}{m_1 + m_2}\right)^2 - (m_1v_{1i}^2 + m_2v_{2i}^2)$$

$$(m_1 + m_2)2\Delta KE = m_1^2v_{1i}^2 + 2m_1m_2v_{1i}v_{2i} + m_2^2v_{2i}^2 - (m_1 + m_2)m_1v_{1i}^2 + (m_1 + m_2)m_2v_{2i}^2$$

$$2(m_1 + m_2)\Delta KE = 2m_1m_2v_{1i}v_{2i} - m_1m_2v_{1i}^2 - m_1m_2v_{2i}^2$$

$$2(m_1 + m_2)\Delta KE = -m_1m_2(v_{1i}^2 - 2v_{1i}v_{2i} + v_{2i}^2) = -m_1m_2(v_{1i} - v_{2i})^2$$

$$\Delta KE = -\frac{1}{2}\left(\frac{m_1m_2}{m_1 + m_2}\right)(v_{1i} - v_{2i})^2$$

$$\Delta KE = -\frac{1}{2}\left(\frac{(6.5 \times 10^{12}\text{ kg})(1.50 \times 10^{13}\text{ kg})}{6.5 \times 10^{12}\text{ kg} + 1.50 \times 10^{13}\text{ kg}}\right)(420\text{ m/s} - 250\text{ m/s})^2$$

$$\Delta KE = -\frac{1}{2}\left(\frac{(6.5 \times 10^{12}\text{ kg})(1.50 \times 10^{13}\text{ kg})}{2.15 \times 10^{13}\text{ kg}}\right)(170\text{ m/s})^2 = -6.6 \times 10^{16}\text{ kg}\bullet\text{m}^2\text{/s}^2$$

$$\Delta KE = \boxed{-6.6 \times 10^{16}\text{ J}}$$

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189. $m_1 = 7.00$ kg

$\mathbf{v_{1,i}} = 2.00$ m/s to the east (at 0°)

$m_2 = 7.00$ kg

$\mathbf{v_{1,i}} = 0$ m/s

$\mathbf{v_{1,f}} = 1.73$ m/s at 30.0° north of east

Momentum conservation

In the *x*-direction:

$m_1v_{1,i}(\cos\theta_{1,i}) + m_2v_{2,i}(\cos\theta_{2,i}) = m_1v_{1,f}(\cos\theta_{1,f}) + m_2v_{2,f}(\cos\theta_{2,f})$

$v_{2,f}(\cos\theta_{2,f}) = v_{1,i}(\cos\theta_{1,i}) + v_{2,i}(\cos\theta_{2,i}) - v_{i,f}(\cos\theta_{1,f})$

$v_{2,f}(\cos\theta_{2,f}) = (2.00 \text{ m/s})(\cos 0°) + 0 \text{ m/s} - (1.73 \text{ m/s})(\cos 30.0°)$

$v_{2,f} = 2.00 \text{ m/s} - 1.50 \text{ m/s} = 0.50 \text{ m/s}$

In the *y*-direction:

$m_1v_{1,i}(\sin\theta_{1,i}) + m_2v_{2,i}(\sin\theta_{2,i}) = m_1v_{1,f}(\sin\theta_{1,i})\ m_2v_{2,f}(\sin\theta_{2,f})$

$v_{2,f}(\sin\theta_{2,f}) = v_{1,i}(\sin\theta_{1,i}) + v_{2,i}(\sin\theta_{2,i}) - v_{2,f}(\sin\theta_{2,f})$

$v_{2,f}(\sin\theta_{2,f}) = (2.00 \text{ m/s})(\sin 0°) + 0 \text{ m/s} - (1.73 \text{ m/s})(\sin 30.0°) = -0.865 \text{ m/s}$

$$\frac{v_{2,f}(\sin\theta_{2,f})}{v_{2,f}(\cos\theta_{2,f})} = \frac{-0.865 \text{ m/s}}{0.50 \text{ m/s}}$$

$\tan\theta_{2,f} = -1.7$

$\theta_{2,f} = \tan^{-1}(-1.7) = (-6.0 \times 10^1)°$

$$v_{2,f} = \frac{0.50 \text{ m/s}}{\cos(-6.0 \times 10^1)°} = 1.0 \text{ m/s}$$

$\mathbf{v_{2,f}} = \boxed{1.0 \text{ m/s at } (6.0 \times 10^1)° \text{ south of east}}$

Conservation of kinetic energy (check)

$\frac{1}{2}m_1v_{1,i}^2 + \frac{1}{2}m_2v_{2,i}^2 = \frac{1}{2}m_1v_{1,f}^2 + \frac{1}{2}m_2v_{2,f}^2$

$\frac{1}{2}(7.00 \text{ kg})(2.00 \text{ m/s})^2 + \frac{1}{2}(7.00 \text{ kg})(0 \text{ m/s})^2 = \frac{1}{2}(7.00 \text{ kg})(1.73 \text{ m/s})^2 + \frac{1}{2}(7.00 \text{ kg})(1.0 \text{ m/s})^2$

$14.0 \text{ J} + 0 \text{ J} = 10.5 \text{ J} + 3.5 \text{ J}$

$14.0 \text{ J} = 14.0 \text{ J}$

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190. $m_1 = 2.0$ kg

$v_{1,i} = 8.0$ m/s

$v_{2,i} = 0$ m/s

$v_{1,f} = 2.0$ m/s

$m_1v_{1,i} + m_2v_{2,i} = m_1v_{1,f} + m_2v_{2,f}$

$\frac{1}{2}m_1v_{1,i}^2 + \frac{1}{2}m_2v_{2,i}^2 = \frac{1}{2}m_1v_{1,f}^2 + \frac{1}{2}m_2v_{2,f}^2$

$$m_2 = \frac{m_1v_{1,f} - m_1v_{1,i}}{v_{2,i} - v_{2,f}}$$

$$\frac{1}{2}m_1v_{1,i}^2 + \frac{1}{2}\left[\frac{m_1v_{1,f} - m_1v_{1,i}}{v_{2,i} - v_{2,f}}\right]v_{2,i}^2 = \frac{1}{2}m_1v_{1,f}^2 + \frac{1}{2}\left(\frac{m_1v_{1,f} - m_1v_{1,i}}{v_{2,i} - v_{2,f}}\right)v_{2,f}^2$$

$v_{1,i}^2(v_{2,i} - v_{2,f}) + (v_{1,f} - v_{1,i})v_{2,i}^2 = v_{1,f}^2(v_{2,i} - v_{2,f}) + (v_{1,f} - v_{1,i})v_{2,f}^2$

$(v_{1,i}^2v_{2,i} + v_{1,f}v_{2,i}^2 - v_{1,i}v_{2,i}^2 - v_{1,f}^2v_{2,i} + v_{2,f}(v_{1,f}^2 - v_{1,i}^2) = v_{2,f}^2(v_{1,f} - v_{1,i})$

Because $v_{2,i} = 0$, the above equation simplifies to

$v_{1,f}^2 - v_{1,i}^2 = v_{2,f}(v_{1,f} - v_{1,i})$

$v_{2,f} = v_{1,f} + v_{1,i} = 2.0 \text{ m/s} + 8.0 \text{ m/s} = 10.0 \text{ m/s}$

$$m_2 = \frac{(2.0 \text{ kg})(2.0 \text{ m/s}) - (2.0 \text{ m/s})(8.0 \text{ m/s})}{0 \text{ m/s} - 10.0 \text{ m/s}} = \frac{4.0 \text{ kg•m/s} - 16 \text{ kg•m/s}}{-10.0 \text{ m/s}} = \frac{-12 \text{ kg•m/s}}{-10.0 \text{ m/s}}$$

$m_2 = \boxed{1.2 \text{ kg}}$

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191. $r = 3.81$ m

$v_t = 124$ m/s

$$a_c = \frac{v_t^2}{r} = \frac{(124 \text{ m/s})^2}{3.81 \text{ m}} = \boxed{4.04 \times 10^3 \text{ m/s}^2}$$

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192. $v_t = 75.0$ m/s

$a_c = 22.0$ m/s^2

$$r = \frac{v_t^2}{a_c} = \frac{(75.0 \text{ m/s})^2}{22.0 \text{ m/s}^2} = \boxed{256 \text{ m}}$$

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193. $r = 8.9$ m

$a_c = (20.0)\ g$

$g = 9.81$ m/s^2

$$v_t = \sqrt{ra_c} = \sqrt{(8.9 \text{ m})(20.0)(9.81 \text{ m/s}^2)} = \boxed{42 \text{ m/s}}$$

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194. $m = 1250$ kg

$v_t = 48.0$ km/h

$r = 35.0$ m

$$F_c = m\frac{v_t^2}{r} = (1250 \text{ kg})\frac{[(48.0 \text{ km/h})(1000 \text{ m/km})(1\text{h}/3600 \text{ s})]^2}{35.0 \text{ m}}$$

$$F_c = 6350 \text{ kg} \bullet \text{m/s}^2 = \boxed{6350 \text{ N}}$$

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195. $F_c = 8.00 \times 10^2$ N

$r = 0.40$ m

$v_t = 6.0$ m/s

$$m = \frac{F_c r}{v_t^2} = \frac{(8.00 \times 10^2 \text{ N})(0.40 \text{ m})}{(6.0 \text{ m/s})^2} = \boxed{8.9 \text{ kg}}$$

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196. $m = 7.55 \times 10^{13}$ kg

$v_t = 0.173$ km/s

$F_c = 505$ N

$$r = \frac{mv_t^2}{F_c} = \frac{(7.55 \times 10^{13} \text{ kg})(0.173 \times 10^3 \text{ m/s})^2}{505 \text{ N}} = \boxed{4.47 \times 10^{15} \text{ m}}$$

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197. $m = 2.05 \times 10^8$ kg

$r = 7378$ km

$F_c = 3.00 \times 10^9$ N

$$v_t = \sqrt{\frac{F_c r}{m}} = \sqrt{\frac{(3.00 \times 10^9 \text{ N})(7378 \times 10^3 \text{ m})}{2.05 \times 10^8 \text{ kg}}}$$

$$v_t = \boxed{1.04 \times 10^4 \text{ m/s} = 10.4 \text{ km/s}}$$

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198. $m_1 = 0.500$ kg

$m_2 = 2.50 \times 10^{12}$ kg

$r = 10.0$ km

$G = 6.673 \times 10^{-11} \dfrac{\text{N}\bullet\text{m}^2}{\text{kg}^2}$

$$F_g = G\frac{m_1 m_2}{r^2} = \left(6.673 \times 10^{-11} \frac{\text{N}\bullet\text{m}^2}{\text{kg}^2}\right)\frac{(0.500 \text{ kg})(2.50 \times 10^{12} \text{ kg})}{(10.0 \times 10^3 \text{ m})^2} = \boxed{8.34 \times 10^{-7} \text{ N}}$$

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199. $F_g = 1.636 \times 10^{22}$ N

$m_1 = 1.90 \times 10^{27}$ kg

$r = 1.071 \times 10^6$ km

$G = 6.673 \times 10^{-11} \dfrac{\text{N}\bullet\text{m}^2}{\text{kg}^2}$

$$m_2 = \frac{F_g r^2}{Gm_1} = \frac{(1.636 \times 10^{22} \text{ N})(1.071 \times 10^9 \text{ m})^2}{\left(6.673 \times 10^{-11} \dfrac{\text{N}\bullet\text{m}^2}{\text{kg}^2}\right)(1.90 \times 10^{27} \text{ kg})} = \boxed{1.48 \times 10^{23} \text{ kg}}$$

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200. $m_1 = 1.00$ kg $m_2 = 1.99 \times 10^{30}$ kg $F_g = 274$ N $G = 6.673 \times 10^{-11} \frac{N \bullet m^2}{kg^2}$	$r = \sqrt{\frac{Gm_1m_2}{F_g}} = \sqrt{\frac{\left(6.673 \times 10^{-11} \frac{N \bullet m^2}{kg^2}\right)(1.00\ kg)(1.99 \times 10^{30}\ kg)}{274\ N}} = \boxed{6.96 \times 10^8\ m}$
201. $m_1 = 1.00$ kg $m_2 = 3.98 \times 10^{31}$ kg $F_g = 2.19 \times 10^{-3}$ N $G = 6.673 \times 10^{-11} \frac{N \bullet m^2}{kg^2}$	$r = \sqrt{\frac{Gm_1m_2}{F_g}} = \sqrt{\frac{\left(6.673 \times 10^{-11} \frac{N \bullet m^2}{kg^2}\right)(1.00\ kg)(3.98 \times 10^{31}\ kg)}{2.19 \times 10^{-3}\ N}} = \boxed{1.10 \times 10^{12}\ m}$
202. $m = 8.6 \times 10^{25}$ kg $r = 1.3 \times 10^5$ km $= 1.3 \times 10^8$ m $G = 6.673 \times 10^{-11}\ N \bullet m^2/kg^2$	$T = 2\pi\sqrt{\frac{r^3}{Gm}} = 2\pi\sqrt{\frac{(1.3 \times 10^8\ m)^3}{\left(6.673 \times 10^{-11} \frac{N \bullet m^2}{kg^2}\right)(8.6 \times 10^{25}\ kg)}} = \boxed{1.2 \times 10^5\ m}$ $T = 1.2 \times 10^5\ s \left(\frac{1\ h}{3600\ s}\right) = \boxed{34\ h}$
203. $m = 8.6 \times 10^{25}$ kg $r = 1.3 \times 10^5$ km $= 1.3 \times 10^8$ m $G = 6.673 \times 10^{-11}\ N \bullet m^2/kg^2$	$v_t = \sqrt{\frac{Gm}{r}} = \sqrt{\frac{\left(6.673 \times 10^{-11} \frac{N \bullet m^2}{kg^2}\right)(8.6 \times 10^{25}\ kg)}{(1.3 \times 10^8\ m)}}$ $v_t = \boxed{6.6 \times 10^3\ m/s = 6.6\ km/s}$
204. $F_{max} = 2.27 \times 10^5\ N \bullet m$ $r = 0.660$ m $d = \frac{1}{2}r$	$\tau_{max} = F_{max}d = \frac{F_{max}r}{2}$ $\tau_{max} = \frac{(2.27 \times 10^5\ N \bullet m)(0.660\ m)}{2} = \boxed{7.49 \times 10^4\ N \bullet m}$
205. $\tau = 0.46\ N \bullet m$ $F = 0.53$ N $\theta = 90°$	$d = \frac{\tau}{F(\sin \theta)} = \frac{0.46\ N \bullet m}{(0.53\ N)(\sin 90°)}$ $d = \boxed{0.87\ m}$
206. $m = 6.42 \times 10^{23}$ kg $T = 30.3$ h $G = 6.673 \times 10^{-11}\ N \bullet m^2/kg^2$	$r = \sqrt[3]{\frac{GmT^2}{4\pi^2}} = \sqrt[3]{\frac{\left(6.673 \times 10^{-11} \frac{N \bullet m^2}{kg^2}\right)(6.42 \times 10^{23}\ kg)[(30.3\ h)(3600\ s/h)]^2}{4\pi^2}}$ $r = \sqrt[3]{1.29 \times 10^{22}\ m^3} = \boxed{2.35 \times 10^7\ m = 2.35 \times 10^4\ km}$
207. $d = 1.60$ m $\tau = 4.00 \times 10^2\ N \bullet m$ $\theta = 80.0°$	$F = \frac{\tau}{d(\sin \theta)} = \frac{4.00 \times 10^2\ N \bullet m}{(1.60\ m)(\sin 80.0°)}$ $F = \boxed{254\ N}$
208. $r = 11$ m $v_t = 1.92 \times 10^{-2}$ m/s	$a_c = \frac{v_t^2}{r} = \frac{(1.92 \times 10^{-2}\ m/s)^2}{11\ m} = \boxed{3.4 \times 10^{-5}\ m/s^2}$

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209. $v_t = 0.35$ m/s $a_c = 0.29$ m/s^2	$r = \frac{v_t^2}{a_c} = \frac{(0.35 \text{ m/s})^2}{0.29 \text{ m/s}^2} = \boxed{0.42 \text{ m} = 42 \text{ cm}}$
210. $a_c = g = 9.81$ m/s^2 $r = 150$ m	$v_t = \sqrt{ra_c} = \sqrt{(150 \text{ m})(9.81 \text{ m/s}^2)} = \boxed{38 \text{ m/s}}$
211. $r = 0.25$ m $v_t = 5.6$ m/s $m = 0.20$ kg	$F_c = m\frac{v_t^2}{r} = (0.20 \text{ kg})\frac{(5.6 \text{ m/s})^2}{0.25 \text{ m}} = \boxed{25 \text{ N}}$
212. $m = 1250$ kg $r = 35.0$ m $\theta = 9.50°$ $g = 9.81$ m/s^2 $\mu_k = 0.500$	$F = F_f + mg(\sin\theta) = \mu_k F_n + mg(\sin\theta) = \mu_k mg(\cos\theta) + mg(\sin\theta)$ $F = (0.500)(1250 \text{ kg})(9.81 \text{ m/s}^2)(\cos 9.50°) + (1250 \text{ kg})(9.81 \text{ m/s}^2)(\sin 9.50°)$ $F = 6.05 \times 10^3 \text{ N} + 2.02 \times 10^3 \text{ N}$ $F = \boxed{8.07 \times 10^3 \text{ N}}$ $Fc = \text{F} = 8.07 \times 10^3$ N $v_t = \sqrt{\frac{F_c r}{m}} = \sqrt{\frac{(8.07 \times 10^3 \text{ N})(35.0 \text{ m})}{1250 \text{ kg}}}$ $v_t = \boxed{15.0 \text{ m/s} = 54.0 \text{ km/h}}$
213. $F_g = 2.77 \times 10^{-3}$ N $r = 2.50 \times 10^{-2}$ m $m_1 = 157$ kg $G = 6.673 \times 10^{-11} \frac{\text{N}\bullet\text{m}^2}{\text{kg}^2}$	$m_2 = \frac{F_g r^2}{Gm_1} = \frac{(2.77 \times 10^{-3} \text{ N})(2.50 \times 10^{-2} \text{ m})^2}{\left(6.673 \times 10^{-11} \frac{\text{N}\bullet\text{m}^2}{\text{kg}^2}\right)(157 \text{ kg})} = \boxed{165 \text{ kg}}$
214. $m_1 = 2.04 \times 10^4$ kg $m_2 = 1.81 \times 10^5$ kg $r = 1.5$ m $G = 6.673 \times 10^{-11} \frac{\text{N}\bullet\text{m}^2}{\text{kg}^2}$	$F_g = G\frac{m_1 m_2}{r^2} = \left(6.673 \times 10^{-11} \frac{\text{N}\bullet\text{m}^2}{\text{kg}^2}\right)\frac{(2.04 \times 10^4 \text{ kg})(1.81 \times 10^5 \text{ kg})}{(1.5 \text{ m})^2} = \boxed{0.11 \text{ N}}$
215. $r = 3.56 \times 10^5$ km $= 3.56 \times 10^8$ m $m = 1.03 \times 10^{26}$ kg $G = 6.673 \times 10^{-11}$ N$\bullet$m^2/kg^2	$T = 2\pi\sqrt{\frac{r^3}{Gm}} = 2\pi\sqrt{\frac{(3.56 \times 10^8 \text{ m})^3}{\left(6.673 \times 10^{-11} \frac{\text{N}\bullet\text{m}^2}{\text{kg}^2}\right)(1.03 \times 10^{26} \text{ kg})}}$ $T = 5.09 \times 10^5 \text{ s}\left(\frac{1 \text{ h}}{3600 \text{ s}}\right) = \boxed{141 \text{ h}}$
216. $r = 3.56 \times 10^5$ km $= 3.56 \times 10^8$ m $m = 1.03 \times 10^{26}$ kg $G = 6.673 \times 10^{-11}$ N$\bullet$m^2/kg^2	$v_t = \sqrt{\frac{Gm}{r}} = \sqrt{\frac{\left(6.673 \times 10^{-11} \frac{\text{N}\bullet\text{m}^2}{\text{kg}^2}\right)(1.03 \times 10^{26} \text{ kg})}{(3.56 \times 10^8 \text{ m})}}$ $v_t = \boxed{4.39 \times 10^3 \text{ m/s} = 4.39 \text{ km/s}}$

Givens	*Solutions*
217. $m = 1.0 \times 10^{26}$ kg $T = 365$ days $G = 6.673 \times 10^{-11}$ $N \bullet m^2/kg^2$	$r = \sqrt[3]{\frac{GmT^2}{4\pi^2}} = \sqrt[3]{\frac{(6.673 \times 10^{-11}\ N{\bullet}m^2/kg^2)(1.0 \times 10^{26}\ kg)[(365\ days)(24\ h/day)(3600\ s/h)]^2}{4\pi^2}}$ $r = \boxed{5.5 \times 10^9\ m = 5.5 \times 10^6\ km}$
218. $\tau = 1.4$ N • m $d = 0.40$ m $\theta = 60.0°$	$F = \frac{\tau}{d(\sin\theta)} = \frac{1.4\ N \bullet m}{(0.40\ m)(\sin 60.0°)}$ $F = \boxed{4.0\ N}$
219. $F = 4.0$ N $d = 0.40$ m	τ_{max} is produced when $\theta = 90°$, or $\tau_{max} = Fd = (4.0\ N)(0.40\ m) = \boxed{1.6\ N \bullet m}$
220. $\tau = 8.25 \times 10^3$ N • m $F = 587$ N $\theta = 65.0°$	$d = \frac{\tau}{F(\sin\theta)} = \frac{8.25 \times 10^3\ N \bullet m}{(587\ N)(\sin 65.0°)}$ $d = \boxed{15.5\ m}$

Fluid Mechanics

221. $\rho_{gasoline} = 675\ kg/m^3$ $V_s = 1.00\ m^3$ $g = 9.81\ m/s^2$	$F_B = F_g \frac{\rho_{gasoline}}{\rho_s} = \frac{m_s g}{\rho_s} \rho_{gasoline} = V_s g \rho_{gasoline}$ $F_B = (1.00\ m^3)(9.81\ m/s^2)(675\ kg/m^3) = \boxed{6.62 \times 10^3\ N}$
222. $\rho_r = 2.053 \times 10^4 kg/m^3$ $V_r = (10.0\ cm)^3$ $g = 9.81\ m/s^2$ apparent weight = 192 N	$F_B = F_g -$ apparent weight $F_B = m_r g -$ apparent weight $= \rho_r V_r g -$ apparent weight $F_B = (2.053 \times 10^4\ kg/m^3)(10.0\ cm)^3(10^{-2}\ m/cm)^3(9.81\ m/s^2) - 192\ N = 201\ N - 192\ N$ $F_B = \boxed{9\ N}$
223. $m_h = 1.47 \times 10^6$ kg $A_h = 2.50 \times 10^3\ m^2$ $\rho_{sw} = 1.025 \times 10^3\ kg/m^3$ $g = 9.81\ m/s^2$	$F_B = F_g = m_h g$ $F_B = (1.47 \times 10^6\ kg)(9.81\ m/s^2) = 1.44 \times 10^7\ N$ volume of hull submerged $= V_{sw} = \frac{m_{sw}}{\rho_{sw}} = \frac{m_h}{\rho_{sw}}$ $h = \frac{V_{sw}}{A_h} = \frac{m_h}{A_h \rho_{sw}}$ $h = \frac{1.47 \times 10^6\ kg}{(2.50 \times 10^3\ m^2)(1.025 \times 10^3\ kg/m^3)} = \boxed{0.574\ m}$
224. $A = 1.54\ m^2$ $P = 1.013 \times 10^3$ Pa	$F = PA = (1.013 \times 10^3\ Pa)(1.54\ m^2) = \boxed{1.56 \times 10^3\ N}$

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Givens	*Solutions*
225. $P = 1.50 \times 10^6$ Pa $F = 1.22 \times 10^4$ N	$A = \frac{F}{P} = \frac{1.22 \times 10^4 \text{ N}}{1.50 \times 10^6 \text{ Pa}} = \boxed{8.13 \times 10^{-3} \text{ m}^2}$
226. $h = 760$ mm $\rho = 13.6 \times 10^3$ kg/m^3 $g = 9.81$ m/s^2	$P = \frac{F}{A} = \frac{mg}{A} = \frac{mgh}{Ah} = \frac{mgh}{V} = \rho gh$ $P = (13.6 \times 10^3 \text{ kg/m}^3)(9.81 \text{ m/s}^2)(760 \times 10^{-3} \text{ m}) = \boxed{1.0 \times 10^5 \text{ Pa}}$
227. $V = 166$ cm^3 apparent weight = 35.0 N $\rho_w = 1.00 \times 10^3$ kg/m^3 $g = 9.81$ m/s^2	$F_g = F_B +$ apparent weight $\rho_{osmium} Vg = \rho_w Vg +$ apparent weight $\rho_{osmium} = \rho_w + \frac{\text{apparent weight}}{Vg}$ $\rho_{osmium} = 1.00 \times 10^3 \text{ kg/m}^3 + \frac{35.0 \text{ N}}{(166 \text{ cm}^3)(10^{-6} \text{ m}^3/\text{cm}^3)(9.81 \text{ m/s}^2)}$ $\rho_{osmium} = 1.00 \times 10^3 \text{ kg/m}^3 + 2.15 \times 10^4 \text{ kg/m}^3$ $\rho_{osmium} = \boxed{2.25 \times 10^4 \text{ kg/m}^3}$
228. $V = 2.5 \times 10^{-3}$ m^3 apparent weight = 7.4 N $\rho_w = 1.0 \times 10^3$ kg/m^3 $g = 9.81$ m/s^2	$F_g = F_B +$ apparent weight $\rho_{ebony} V_g = \rho_w V_g +$ apparent weight $\rho_{ebony} = \rho_w + \frac{\text{apparent weight}}{V_g}$ $\rho_{ebony} = 1.0 \times 10^3 \text{ kg/m}^3 + \frac{7.4 \text{ N}}{(2.5 \times 10^{-3} \text{ m}^3)(9.81 \text{ m/s}^2)}$ $= 1.0 \times 10^3 \text{ kg/m}^3 + 3.0 \times 10^2 \text{ kg/m}^3$ $\rho_{ebony} = \boxed{1.3 \times 10^3 \text{ kg/m}^3}$
229. $m = 1.40 \times 10^3$ kg $h = 0.076$ m $\rho_{ice} = 917$ kg/m^3	$P_1 = P_2$ $\frac{F_1}{A_1} = \frac{F_2}{A_2}$ $\frac{mg}{A_1} = \frac{m_{ice}g}{A_2} = \frac{m_{ice}hg}{V_{ice}} = \rho_{ice}hg$ $A_1 = \frac{m}{\rho_{ice}h} = \frac{1.40 \times 10^3 \text{ kg}}{(917 \text{ kg/m}^3)(0.076 \text{ m})} = \boxed{2.0 \times 10^1 \text{ m}^2}$
230. $F_1 = 4.45 \times 10^4$ N $h_1 = 448$ m $h_2 = 8.00$ m	$P_1 = P_2$ $\frac{F_1}{A_1} = \frac{F_2}{A_2}$ $\frac{F_1h_1}{A_1h_1} = \frac{F_1h_1}{V} = \frac{F_2h_2}{A_2h_2} = \frac{F_2h_2}{V}$ $F_2 = \frac{F_1h_1}{h_2} = \frac{(4.45 \times 10^4 \text{ N})(448 \text{ m})}{8.00 \text{ m}}$ $F_2 = \boxed{2.49 \times 10^6 \text{ N}}$

Givens | *Solutions*

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231. $\rho_{platinum} = 21.5\ \text{g/cm}^3$

$\rho_w = 1.00\ \text{g/cm}^3$

apparent weight = 40.2 N

$g = 9.81\ \text{m/s}^2$

$$F_g = F_B + \text{apparent weight}$$

$$mg = \rho_w V g + \text{apparent weight} = \rho_w\left(\frac{m}{\rho_{platinum}}\right)g + \text{apparent weight}$$

$$mg\left(1 - \frac{\rho_w}{\rho_{platinum}}\right) = \text{apparent weight}$$

$$m = \frac{\text{apparent weight}}{g\left(1 - \frac{\rho_w}{\rho_{platinum}}\right)} = \frac{40.2\ \text{N}}{(9.81\ \text{m/s}^2)\left(1 - \frac{1.00\ \text{g/cm}^3}{21.5\ \text{g/cm}^3}\right)}$$

$$m = \frac{40.2\ \text{N}}{(9.81\ \text{m/s}^2)(1 - 0.047)} = \frac{40.2\ \text{N}}{(9.81\ \text{m/s}^2)(0.953)}$$

$$m = \boxed{4.30\ \text{kg}}$$

Heat

232. $T_1 = 463\ \text{K}$

$T_2 = 93\ \text{K}$

$$T_{C,1} = (T - 273)°\text{C} = (463 - 273)°\text{C} = \boxed{1.90 \times 10^2\ °\text{C}}$$

$$T_{C,2} = (T - 273)°\text{C} = (93 - 273)°\text{C} = \boxed{-180 \times 10^2\ °\text{C}}$$

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233. $T_1 = 463\ \text{K}$

$T_2 = 93\ \text{K}$

$$T_{F,1} = \frac{9}{5}\ T_{C,1} + 32 = \frac{9}{5}\ (1.90 \times 10^2)°\text{F} + 32°\text{F} = 342°\text{F} + 32°\text{F} = \boxed{374°\text{F}}$$

$$T_{F,2} = \frac{9}{5}\ T_{C,2} + 32 = \frac{9}{5}\ (-1.80 \times 10^2)°\text{F} + 32°\text{F} = -324°\text{F} + 32°\text{F} = \boxed{-292°\text{F}}$$

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234. $T_{F,i} = -5\ °\text{F}$

$T_{F,f} = +37°\text{F}$

$$T_{C,i} = \frac{5}{9}(T_{F,i} - 32)°\text{C} = \frac{5}{9}(-5 - 32)°\text{C} = \frac{5}{9}(-37)°\text{C} = -21°\text{C}$$

$$T_{C,f} = \frac{5}{9}(T_{F,f} - 32)°\text{C} = \frac{5}{9}(37 - 32)°\text{C} = \frac{5}{9}(5)°\text{C} = 3°\text{C}$$

$$\Delta T = (T_{C,f} + 273\ \text{K}) - (T_{C,i} + 273\ \text{K}) = T_{C,f} - T_{C,i}$$

$$\Delta T = [3 - (-21)]\ \text{K} = \boxed{24\ \text{K}}$$

Givens	*Solutions*
235. $h = 9.5$ m	$\Delta PE + \Delta KE + \Delta U = 0$
$g = 9.81\ \mathrm{m/s^2}$	The change in kinetic energy from before the acorn is dropped to after it has landed is zero, as is PE_f.
$\Delta U_{acorn} = (0.85)\Delta U$	$\Delta PE + \Delta KE + \Delta U = PE_f - PE_i + 0 + \Delta U = -PE_i + \Delta U = 0$
$k/m = \dfrac{1200\ \mathrm{J/kg}}{1.0°\mathrm{C}}$	$\Delta U = PE_i = mgh$
	$\Delta U_{acorn} = (0.85)\ \Delta U = (0.85)mgh$
	$\Delta T = \dfrac{\Delta U_{acorn}}{k} = \dfrac{(0.85)mgh}{k} = \dfrac{(0.85)gh}{(k/m)}$
	$\Delta T = \dfrac{(0.85)(9.81\ \mathrm{m/s^2})(9.5\ \mathrm{m})}{\left(\dfrac{1200\ \mathrm{J/kg}}{1.0°\mathrm{C}}\right)} = \boxed{6.6 \times 10^{-2}\ °\mathrm{C}}$

236. $v_f = 0$ m/s	$\Delta PE + \Delta KE + \Delta U = 0$
$v_i = 13.4$ m/s	The bicyclist remains on the bicycle, which does not change elevation, so $\Delta PE = 0$ J.
$\Delta U = 5836$ J	$\Delta KE = KE_f - KE_i = 0 - \frac{1}{2}mv_i^2 = -\Delta U$
	$m = \dfrac{2\Delta U}{v_i^2} = \dfrac{(2)(5836\ \mathrm{J})}{(13.4\ \mathrm{m/s})^2} = \boxed{65.0\ \mathrm{kg}}$

237. $v_i = 20.5$ m/s	$\Delta PE + \Delta E + \Delta U = 0$
$v_f = 0$ m/s	The height of the skater does not change, so $\Delta PE = 0$ J.
$m = 61.4$ kg	$\Delta KE = KE_f - KE_i = 0 - \frac{1}{2}mv_i^2$
	$\Delta U = -\Delta KF = -(-\frac{1}{2}mv_i^2) = \frac{1}{2}(61.4\ \mathrm{kg})(20.5\ \mathrm{m/s})^2 = \boxed{1.29 \times 10^4\ \mathrm{J}}$

238. $m_t = 0.225$ kg	$c_{p,t} = \dfrac{Q}{m_t \Delta T_t}$
$c_{p,t} = 2.2 \times 10^3\ \mathrm{J/kg \bullet °C}$	
$Q = -3.9 \times 10^4$ J	$\Delta T_t = \dfrac{Q}{m_t c_{p,t}} = \dfrac{-3.9 \times 10^4\ \mathrm{J}}{(0.225\ \mathrm{kg})(2.2 \times 10^3\ \mathrm{J/kg \bullet °C})} = \boxed{-79°\mathrm{C}}$

239. $c_{p,b} = 121\ \mathrm{J/kg \bullet °C}$	$c_{p,b} = \dfrac{Q}{m_b \Delta T_b}$
$Q = 25$ J	
$\Delta T_b = 5.0°\mathrm{C}$	$m_b = \dfrac{Q}{c_{p,b}\Delta T_b} = \dfrac{25\ \mathrm{J}}{(121\ \mathrm{J/kg \bullet °C})(5.0°\mathrm{C})} = \boxed{4.1 \times 10^{-2}\ \mathrm{kg}}$

240. $m_a = 0.250$ kg	$-c_{p,a}m_a\Delta T_a = c_{p,w}m_w\Delta T_w$
$m_w = 1.00$ kg	$c_{pa} = -\dfrac{c_{p,w}m_w\Delta T_w}{m_a\Delta T_a} = -\dfrac{(4186\ \mathrm{J/kg \bullet °C})(1.00\ \mathrm{kg})(1.00°\mathrm{C})}{(0.25\ \mathrm{kg})(-17.5°\ \mathrm{C})}$
$\Delta T_w = 1.00°\ \mathrm{C}$	$c_{p,a} = \boxed{957\ \mathrm{J/kg \bullet °C}}$
$\Delta T_a = -17.5°\ \mathrm{C}$	
$c_{p,w} = 4186\ \mathrm{J/kg \bullet °C}$	

241. $T_F = 2192°\mathrm{F}$	$T_C = \dfrac{5}{9}(T_F - 32)°\mathrm{C} = \dfrac{5}{9}(2192 - 32)°\mathrm{C} = \dfrac{5}{9}(2.160 \times 10^3)°\mathrm{C}$
	$T_C = \boxed{1.200 \times 10^3 °\mathrm{C}}$

242. $T = 2.70$ K	$T_C = (T - 273)°\mathrm{C} = (2.70 - 273)°\mathrm{C} = \boxed{-270°\mathrm{C}}$

Givens	*Solutions*
243. $T = 42°C$	$T = (T + 273)K = (42 + 273)\ K = \boxed{315\ K}$
244. $\Delta KE = 2.15 \times 10^4$ J $\Delta U_{air} = 33\%\Delta KE$ $\Delta PE = 0$ J	$\Delta PE + \Delta KE + \Delta U = 0$ $\Delta PE + \Delta KE - \Delta U_{sticks} - \Delta U_{air} = 0$ $\Delta U_{sticks} = \Delta KE - \Delta U_{air} = \Delta KE - 0.33\Delta KE = 0.67\Delta KE$ $\Delta U_{sticks} = 0.667(2.15 \times 10^4\ J) = \boxed{1.4 \times 10^4\ J}$
245. $h = 561.7$ m $\Delta U = 105$ J $g = 9.81\ m/s^2$	$\Delta PE = \Delta KE + \Delta U = 0$ When the stone lands, its kinetic energy is transferred to the internal energy of the stone and the ground. Therefore, overall, $\Delta KE = 0$ J $\Delta PE = PE_f - PE_e = 0 - mgh = -\Delta U$ $m = \frac{\Delta U}{gh} = \frac{105\ J}{(9.81\ m/s^2)(561.7\ m)} = 1.91 \times 10^{-2}\ kg = \boxed{19.1\ g}$
246. $m = 2.5$ kg $v_i = 5.7$ m/s 3.3×10^5 J melts 1.0 kg of ice	$\Delta U = KE_i = \frac{1}{2}mv_i^2 = \frac{1}{2}(2.5\ kg)(5.7\ m/s)^2 = 41\ J$ ice melted $= \frac{(41\ J)(1.0\ kg)}{3.3 \times 10^5\ J} = \boxed{1.2 \times 10^{-4}\ kg}$
247. $m_i = 3.0$ kg $m_w = 5.0$ kg $\Delta T_w = 2.25°$ C $\Delta T_i = -29.6°$ C $c_{p,w} = 4186$ J/kg • °C	$-c_{p,i}m_i\Delta T_i = c_{p,w}m_w\Delta T_w$ $c_{p,i} = -\frac{c_{p,w}m_w\Delta T_w}{m_i\Delta T_i} = -\frac{(4186\ J/kg \bullet °C)(5.0\ kg)(2.25°C)}{(3.0\ kg)(-29.6°C)}$ $c_{p,i} = \boxed{530\ J/kg \bullet °C}$
248. $Q = 45 \times 10^6$ J $\Delta T_a = 55°$ C $c_{p,a} = 1.0 \times 10^3$ J/kg • °C	$c_{p,a} = \frac{Q}{m_a\Delta T_a}$ $m_a = \frac{Q}{c_{p,a}\Delta T_a} = \frac{45 \times 10^6\ J}{(1.0 \times 10^3\ J/kg \bullet °C)(55°C)}_a = \boxed{820\ kg}$
249. $c_{p,t} = 140$ J/kg • °C $m_t = 0.23$ kg $Q = -3.0 \times 10^4$ J	$c_{p,t} = \frac{Q}{m_t\Delta T_t}$ $\Delta T_t = \frac{Q}{m_t c_{p,t}} = \frac{-3.0 \times 10^4\ J}{(0.23\ kg)(140\ J/kg \bullet °C)} = \boxed{-930°C}$

Thermodynamics

250. $P = 2.07 \times 10^7$ Pa $\Delta V = 0.227\ m^3$	$W = P\Delta V = (2.07 \times 10^7\ Pa)(0.227\ m^3) = \boxed{4.70 \times 10^6\ J}$

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Givens	*Solutions*
251. $W = 3.29 \times 10^6$ J $\Delta V = 2190$ m^3	$P = \frac{W}{\Delta V} = \frac{3.29 \times 10^6 \text{ J}}{2190 \text{ m}^3} = 1.50 \times 10^3 \text{ Pa} = \boxed{1.50 \text{ kPa}}$
252. $W = 472.5$ J $P = 25.0 \text{ kPa} = 2.50 \times 10^4 \text{ Pa}$	$\Delta V = \frac{W}{P} = \frac{472.5 \text{ J}}{2.50 \times 10^4 \text{ Pa}} = \boxed{1.89 \times 10^{-2} \text{ m}^3}$
253. $\Delta U = 873$ J	$\Delta V = 0$, so $W = 0$ J $\Delta U = Q - W$ $Q = \Delta U + W = 873 \text{ J} + 0 \text{ J} = \boxed{873 \text{ J}}$
254. $U_i = 39$ J $U_f = 163$ J $Q = 114$ J	$\Delta U = U_f - U_i = Q - W$ $W = Q - \Delta U = Q - (U_f - U_i) = Q - U_f + U_i$ $W = 114 \text{ J} - 163 \text{ J} + 39 \text{ J} = \boxed{-10 \text{ J}}$
255. $Q = 867$ J $W = 623$ J	$\Delta U = Q - W = 867 \text{ J} - 623 \text{ J} = \boxed{244 \text{ J}}$
256. $eff = 0.29$ $Q_h = 693$ J	$W_{net} = eff\, Q_h = (0.29)(693 \text{ J}) = \boxed{2.0 \times 10^2 \text{ J}}$
257. $eff = 0.19$ $W_{net} = 998$ J	$Q_h = \frac{W_{net}}{eff} = \frac{998 \text{ J}}{0.19} = \boxed{5.3 \times 10^3 \text{ J}}$
258. $Q_h = 571$ J $Q_c = 463$ J	$eff = 1 - \frac{Q_c}{Q_h} = 1 - \frac{463 \text{ J}}{571 \text{ J}} = 1 - 0.811 = \boxed{0.189}$
259. $W = 1.3$ J $\Delta V = 5.4 \times 10^{-4}$ m^3	$P = \frac{W}{\Delta V} = \frac{1.3 \text{ J}}{5.4 \times 10^{-4} \text{ m}^3} = 2.4 \times 10^3 \text{ Pa} = \boxed{2.4 \text{ kPa}}$
260. $W = 393$ J $P = 655 \text{ kPa} = 6.55 \times 10^5 \text{ Pa}$	$\Delta V = \frac{W}{P} = \frac{393 \text{ J}}{6.55 \times 10^5 \text{ Pa}} = \boxed{6.00 \times 10^{-4} \text{ m}^3}$
261. $U_i = 8093$ J $U_f = 2.092 \times 10^4$ J $Q = 6932$ J	$\Delta U = U_f - U_i = Q - W$ $W = Q - \Delta U = Q - (U_f - U_i) = Q - U_f + U_i$ $W = 6932 \text{ J} - 2.092 \times 10^4 \text{ J} + 8093 \text{ J} = \boxed{-5895 \text{ J}}$
262. $W = 192$ kJ $\Delta U = 786$ kJ	$\Delta U = Q - W$ $Q = \Delta U + W = 786 \text{ kJ} + 192 \text{ kJ} = \boxed{978 \text{ kJ}}$
263. $Q = 632$ kJ $W = 102$ kJ	$\Delta U = Q - W = 632 \text{ kJ} - 102 \text{ kJ} = 5.30 \times 10^2 \text{ kJ} = \boxed{5.30 \times 10^5 \text{ J}}$

Givens	*Solutions*
264. $eff = 0.35$ $Q_h = 7.37 \times 10^8$ J	$W_{net} = eff\, Q_h = (0.35)(7.37 \times 10^8 \text{ J}) = \boxed{2.6 \times 10^8 \text{ J}}$
265. $eff = 0.11$ $W_{net} = 1150$ J	$Q_h = \frac{W_{net}}{eff} = \frac{1150 \text{ J}}{0.11} = \boxed{1.0 \times 10^4 \text{ J}}$
266. $W_{net} = 128$ J $Q_h = 581$ J	$eff = \frac{W_{net}}{Q_h} = \frac{128 \text{ J}}{581 \text{ J}} = \boxed{0.220}$

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Vibrations and Waves

267. $k = 420$ N/m $x = 4.3 \times 10^{-2}$ m	$F_{elastic} = -kx = -(420 \text{ N/m})(4.3 \times 10^{-2} \text{ m}) = \boxed{-18 \text{ N}}$
268. $F_g = -669$ N $x = -6.5 \times 10^{-2}$ m	$F_{net} = 0 = F_{elastic} + F_g = -kx + F_g$ $F_g = kx$ $k = \frac{F_g}{x} = \frac{-669 \text{ N}}{-6.5 \times 10^{-2} \text{ m}} = \boxed{1.0 \times 10^4 \text{ N/m}}$
269. $F_{elastic} = 52$ N $k = 490$ N/m	$F_{elastic} = -kx$ $x = -\frac{F_{elastic}}{k} = -\frac{52 \text{ N}}{490 \text{ N/m}} = -0.11 \text{ m} = \boxed{-11 \text{ cm}}$
270. $L = 1.14$ m $T = 3.55$ s	$T = 2\pi\sqrt{\frac{L}{g}}$ $T^2 = \frac{4\pi^2 L}{g}$ $g = \frac{4\pi^2 L}{T^2} = \frac{(4\pi^2)(1.14 \text{ m})}{(3.55 \text{ s})^2} = \boxed{3.57 \text{ m/s}^2}$
271. $f = 2.5$ Hz $g = 9.81$ m/s^2	$T = 2\pi\sqrt{\frac{L}{g}} = \frac{1}{f}$ $\frac{1}{f^2} = \frac{4\pi^2 L}{g}$ $L = \frac{g}{4\pi^2 f^2} = \frac{9.81 \text{ m/s}^2}{(4\pi^2)(2.5 \text{ s}^{-1})^2} = \boxed{4.0 \times 10^{-2} \text{ m}}$
272. $L = 6.200$ m $g = 9.819$ m/s^2	$T = 2\pi\sqrt{\frac{L}{g}} = 2\pi\sqrt{\frac{6.200 \text{ m}}{9.819 \text{ m/s}^2}} = \boxed{4.993 \text{ s}}$

Givens	Solutions
273. $L = 6.200$ m $g = 9.819$ m/s^2	$f = \frac{1}{T} = \frac{1}{4.993 \text{ s}} = \boxed{0.2003 \text{ Hz}}$
274. $k = 364$ N/m $m = 24$ kg	$T = 2\pi\sqrt{\frac{m}{k}} = 2\pi\sqrt{\frac{24 \text{ kg}}{364 \text{ N/m}}} = \boxed{1.6 \text{ s}}$
275. $F = 32$ N $T = 0.42$ s $g = 9.81$ m/s^2	$F = mg$ $m = \frac{F}{g} = \frac{32 \text{ N}}{9.81 \text{ m/s}^2} = 3.3 \text{ kg}$ $T = 2\pi\sqrt{\frac{m}{k}}$ $T^2 = \frac{4\pi^2 m}{k}$ $k = \frac{4\pi^2 m}{T^2} = \frac{4\pi^2 F}{gT^2} = \frac{4\pi^2 (32 \text{ N})}{(9.81 \text{ m/s}^2)(0.42 \text{ s})^2} = \boxed{730 \text{ N/m}}$
276. $T = 0.079$ s $k = 63$ N/m	$T = 2\pi\sqrt{\frac{m}{k}}$ $T^2 = \frac{4\pi^2 m}{k}$ $m = \frac{kT^2}{4\pi^2} = \frac{(63 \text{ N/m})(0.079 \text{ s})^2}{4\pi^2} = \boxed{1.0 \times 10^{-2} \text{ kg}}$
277. $f = 2.8 \times 10^5$ Hz $\lambda = 0.51 \text{ cm} = 5.1 \times 10^{-3}$ m	$v = f\lambda = (2.8 \times 10^5 \text{ Hz})(5.1 \times 10^{-3} \text{ m}) = \boxed{1.4 \times 10^3 \text{ m/s}}$
278. $f = 20.0$ Hz $v = 331$ m/s	$v = f\lambda$ $\lambda = \frac{v}{f} = \frac{331 \text{ m/s}}{20.0 \text{ Hz}} = \boxed{16.6 \text{ m}}$
279. $\lambda = 1.1$ m $v = 2.42 \times 10^4$ m/s	$v = f\lambda$ $f = \frac{v}{\lambda} = \frac{2.42 \times 10^4 \text{ m/s}}{1.1 \text{ m}} = \boxed{2.2 \times 10^4 \text{ Hz}}$
280. $k = 65$ N/m $x = -1.5 \times 10^{-1}$ m	$F_{elastic} = -kx = -(65 \text{ N/m})(-1.5 \times 10^{-1} \text{ m}) = \boxed{9.8 \text{ N}}$
281. $F_g = 620$ N $x = 7.2 \times 10^{-2}$ m	$F_{net} = 0 = F_{elastic} + F_g = -kx + F_g$ $F_g = kx$ $k = \frac{F_g}{x} = \frac{620 \text{ N}}{7.2 \times 10^{-2} \text{ m}} = \boxed{8.6 \times 10^3 \text{ N/m}}$

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Givens	Solutions
282. $m = 3.0$ kg $g = 9.81$ m/s^2 $k = 36$ N/m	$F_{net} = 0 = F_{elastic} + F_g = -kx - mg$ $mg = -kx$ $x = -\frac{mg}{k} = -\frac{(3.0 \text{ kg})(9.81 \text{ m/s}^2)}{36 \text{ N/m}} = -0.82 \text{ m} = \boxed{-82 \text{ cm}}$
283. $L = 2.500$ m $g = 9.780$ m/s^2	$T = 2\pi\sqrt{\frac{L}{g}} = 2\pi\sqrt{\frac{2.500 \text{ m}}{9.780 \text{ m/s}^2}} = \boxed{3.177 \text{ s}}$
284. $f = 0.50$ Hz $g = 9.81$ m/s^2	$T = 2\pi\sqrt{\frac{L}{g}} = \frac{1}{f}$ $\frac{1}{f^2} = \frac{4\pi^2 L}{g}$ $L = \frac{g}{4\pi^2 f^2} = \frac{9.81 \text{ m/s}^2}{(4\pi^2)(0.50 \text{ s}^{-1})^2} = 0.99 \text{ m} = \boxed{99 \text{ cm}}$
285. $k = 2.03 \times 10^3$ N/m $f = 0.79$ Hz	$T = 2\pi\sqrt{\frac{m}{k}} = \frac{1}{f}$ $\frac{1}{f^2} = \frac{4\pi^2 m}{k}$ $m = \frac{k}{4\pi^2 f^2} = \frac{2.03 \times 10^3 \text{ N/m}}{(4\pi^2)(0.79 \text{ Hz})^2} = \boxed{82 \text{ kg}}$
286. $f = 87$ N $T = 0.64$ s $g = 9.81$ m/s^2	$k = m\left(\frac{2\pi}{T}\right)^2 = \left(\frac{f}{g}\right)\left(\frac{2\pi}{T}\right)^2 = \left(\frac{87 \text{ N}}{9.81 \text{ m/s}^2}\right)\left(\frac{2\pi}{0.64 \text{ s}}\right)^2 = \boxed{850 \text{ N/m}}$
287. $m = 8.2$ kg $k = 221$ N/m	$T = 2\pi\sqrt{\frac{m}{k}} = 2\pi\sqrt{\frac{8.2 \text{ kg}}{221 \text{ N/m}}} = \boxed{1.2 \text{ s}}$
288. $\lambda = 10.6$ m $v = 331$ m/s	$v = f\lambda$ $f = \frac{v}{\lambda} = \frac{331 \text{ m/s}}{10.6 \text{ m}} = \boxed{31.2 \text{ Hz}}$
289. $\lambda = 2.3 \times 10^4$ m $f = 0.065$ Hz	$v = f\lambda = (0.065 \text{ Hz})(2.3 \times 10^4 \text{ m}) = \boxed{1.5 \times 10^3 \text{ m/s}}$

Givens	*Solutions*
290. $P = 5.88 \times 10^{-5}$ W $Intensity = 3.9 \times 10^{-6}$ W/m^2	$Intensity = \dfrac{P}{4\pi r^2}$ $r = \sqrt{\dfrac{P}{(4\pi)(Intensity)}} = \sqrt{\dfrac{5.88 \times 10^{-5}\ \text{W}}{(4\pi)\ (3.9 \times 10^{-6}\ \text{W/m}^2)}}$ $r = \boxed{1.1\ \text{m}}$
291. $P = 3.5$ W $r = 0.50$ m	$Intensity = \dfrac{P}{4\pi r^2} = \dfrac{3.5\ \text{W}}{(4\pi)(0.50\ \text{m})^2} = \boxed{1.1\ \text{W/m}^2}$
292. $Intensity = 4.5 \times 10^{-4}$ W/m^2 $r = 1.5$ m	$Intensity = \dfrac{P}{4\pi r^2}$ $P = 4\pi r^2\ Intensity = (4\pi)\ (1.5\ \text{m})^2\ (4.5 \times 10^{-4}\ \text{W/m}^2)$ $P = \boxed{1.3 \times 10^{-2}\ \text{W}}$
293. $n = 1$ $v = 499$ m/s $L = 0.850$ m	$f_n = \dfrac{nv}{2\ L}$ $f_1 = \dfrac{(1)(499\ \text{m/s})}{(2)(0.85\ \text{m})} = \boxed{294\ \text{Hz}}$
294. $n = 1$ $f_n = f_1 = 392$ Hz $v = 329$ m/s	$L = n\dfrac{v}{2f} = (1)\dfrac{(329\ \text{m/s})}{2(392\ \text{s}^{-1})} = \boxed{0.420\ \text{Hz}}$
295. $n = 7$ $f_1 = 466.2$ Hz $L = 1.53$ m	$f_n = \dfrac{nv}{4\ L}$ $v = \dfrac{4\ Lf_n}{n} = \dfrac{(4)(1.53\ \text{m})(466.2\ \text{Hz})}{7} = \boxed{408\ \text{m/s}}$
296. $n = 1$ $f_1 = 125$ Hz $L = 1.32$ m	$f_n = \dfrac{nv}{2\ L}$ $v = \dfrac{2Lf_n}{n} = \dfrac{(2)(1.32\ \text{m})(125\ \text{Hz})}{1} = \boxed{330\ \text{m/s}}$
297. $P = 1.57 \times 10^{-3}$ W $Intensity = 5.20 \times 10^{-3}$ W/m^2	$Intensity = \dfrac{P}{4\pi r^2}$ $r = \sqrt{\dfrac{P}{(4\pi)(Intensity)}} = \sqrt{\dfrac{1.57 \times 10^{-3}\ \text{W}}{(4\pi)(5.20 \times 10^{-3}\ \text{W/m}^2)}}$ $r = \boxed{0.155\ \text{m}}$
298. $Intensity = 9.3 \times 10^{-8}$ W/m^2 $r = 0.21$ m	$Intensity = \dfrac{P}{4\pi r^2}$ $P = 4\pi r^2\ Intensity = (4\pi)(0.21\ \text{m})^2\ (9.3 \times 10^{-8}\ \text{W/m}^2)$ $P = \boxed{5.2 \times 10^{-8}\ \text{W}}$

Givens	Solutions
299. $n = 1$ $f_1 = 392.0$ Hz $v = 331$ m/s	$f_n = \frac{nv}{4L}$ $L = \frac{nv}{4f_n} = \frac{(1)(331\text{ m/s})}{(4)(392.0\text{ Hz})} = 0.211\text{ m} = \boxed{21.1\text{ cm}}$
300. $n = 1$ $f_1 = 370.0$ Hz $v = 331$ m/s	$f_n = \frac{nv}{2L}$ $L = \frac{nv}{2f_n} = \frac{(1)(331\text{ m/s})}{(2)(370.0\text{ Hz})} = 0.447\text{ m} = \boxed{44.7\text{ cm}}$

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Light and Reflection

301. $f = 7.6270 \times 10^8$ Hz $\lambda = 3.9296 \times 10^{-1}$ m	$c = f\lambda = (7.6270 \times 10^8\ s^{-1})(3.9296 \times 10^{-1}\text{ m}) = \boxed{2.9971 \times 10^8\text{ m/s}}$ The radio wave travels through Earth's atmosphere.
302. $\lambda = 3.2 \times 10^{-9}$ m	$f = \frac{c}{\lambda} = \frac{3.00 \times 10^8\text{ m/s}}{3.2 \times 10^{-9}\text{ m}} = \boxed{9.4 \times 10^{16}\text{ Hz}}$
303. $f = 9.5 \times 10^{14}$ Hz	$\lambda = \frac{c}{f} = \frac{3.00 \times 10^8\text{ m/s}}{9.5 \times 10^{14}\text{ s}^{-1}} = 3.2 \times 10^{-7}\text{ m} = \boxed{320\text{ nm}}$
304. $f = 17$ cm $q = 23$ cm	$\frac{1}{p} = \frac{1}{f} - \frac{1}{q} = \frac{1}{17\text{ cm}} - \frac{1}{23\text{ cm}} = \frac{23\text{ cm} - 17\text{ cm}}{(17\text{ cm})(23\text{ cm})} = \frac{6\text{ cm}}{(17\text{ cm})(23\text{ cm})}$ $p = \boxed{65\text{ cm}}$
305. $f = 17$ cm $q = 23$ cm $h = 2.7$ cm	$h' = -\frac{qh}{p} = -\frac{(23\text{ cm})(2.7\text{ cm})}{62\text{ cm}} = \boxed{-0.96\text{ cm}}$
306. $f = 9.50$ cm $q = 15.5$ cm	$\frac{1}{p} = \frac{1}{f} - \frac{1}{q} = \frac{1}{9.5\text{ cm}} - \frac{1}{15.5\text{ cm}} = 0.105\text{ cm}^{-1} - 0.0645\text{ cm}^{-1} = 0.0405\text{ cm}^{-1}$ $p = \boxed{24.7\text{ cm}}$
307. $h = 3.0$ cm	$h' = -\frac{qh}{p} = -\frac{(15.5\text{ cm})(3.0\text{ cm})}{25\text{ cm}} = \boxed{-1.9\text{ cm}}$
308. $h = 1.75$ m $M = 0.11$ $q = -42\text{ cm} = -0.42$ m	$M = \frac{h'}{h} = -\frac{q}{p}$ $h' = Mh = (0.11)(1.75\text{ m}) = \boxed{0.19\text{ m}}$
309. $M = 0.11$ $q = -42\text{ cm} = -0.42$ m	$p = -\frac{q}{M} = -\frac{0.42\text{ m}}{0.11} = \boxed{3.8\text{ m}}$

Givens	Solutions
310. $f = -12$ cm $q = -9.0$ cm	$\frac{1}{p} = \frac{1}{f} - \frac{1}{q} = \frac{1}{-12 \text{ cm}} - \frac{1}{-9.0 \text{ cm}} = \frac{0.083}{1 \text{ cm}} + \frac{0.111}{1 \text{ cm}} = \frac{0.028}{1 \text{ cm}}$ $p = \boxed{36 \text{ cm}}$
311. $f = -12$ cm $q = -9.0$ cm	$M = -\frac{q}{p} = -\frac{9.0 \text{ cm}}{36 \text{ cm}} = \boxed{0.25}$
312. $p = 35$ cm $q = 42$ cm	$\frac{1}{f} = \frac{1}{p} + \frac{1}{q} = \frac{2}{R} = \frac{1}{35 \text{ cm}} + \frac{1}{42 \text{ cm}}$ $\frac{1}{f} = \frac{0.029}{1 \text{ cm}} + \frac{0.024}{1 \text{ cm}} = \frac{0.053}{1 \text{ cm}}$ $f = \boxed{19 \text{ cm}}$
313. $p = 35$ cm $q = 42$ cm	$\frac{2}{R} = \frac{1}{f}$ $R = 2f = (2)(19 \text{ cm}) = \boxed{38 \text{ cm}}$
314. $f = 60.0$ cm $p = 35.0$ cm	$\frac{1}{q} = \frac{1}{f} - \frac{1}{p} = \frac{1}{60.0 \text{ cm}} - \frac{1}{35.0 \text{ cm}} = \frac{0.0167}{1 \text{ cm}} - \frac{0.0286}{1 \text{ cm}} = \frac{-0.0119}{1 \text{ cm}}$ $q = \boxed{-84.0 \text{ cm}}$
315. $q = -84.0$ cm $p = 35.0$ cm	$M = -\frac{q}{p} = -\frac{-84.0 \text{ cm}}{35.0 \text{ cm}} = \boxed{2.40}$
316. $q = -5.2$ cm $p = 17$ cm	$\frac{1}{f} = \frac{1}{p} + \frac{1}{q} = \frac{1}{17 \text{ cm}} + \frac{1}{-5.2 \text{ cm}} = \frac{0.059}{1 \text{ cm}} - \frac{0.19}{1 \text{ cm}} = \frac{-0.13}{1 \text{ cm}}$ $f = \boxed{-7.7 \text{ cm}}$

Givens	*Solutions*
317. $q = -5.2$ cm $p = 17$ cm $h = 3.2$ cm	$h' = -\frac{qh}{p} = -\frac{(-5.2\text{ cm})(3.2\text{ cm})}{17\text{ cm}} = \boxed{0.98\text{ cm}}$
318. $\lambda = 5.291\,770 \times 10^{-11}$ m	$f = \frac{c}{\lambda} = \frac{3.00 \times 10^8\text{ m/s}}{5.291\,770 \times 10^{-11}\text{ m}} = \boxed{5.67 \times 10^{18}\text{ Hz}}$
319. $f = 2.85 \times 10^9$ Hz	$\lambda = \frac{c}{f} = \frac{3.00 \times 10^8\text{ m/s}}{2.85 \times 10^9\text{ s}^{-1}} = 0.105\text{ m} = \boxed{10.5\text{ cm}}$
320. $f_1 = 1800$ MHz $= 1.8 \times 10^9$ Hz $f_2 = 2000$ MHz $= 2.0 \times 10^9$ Hz	$\lambda_1 = \frac{c}{f_1} = \frac{3.00 \times 10^8\text{ m/s}}{1.8 \times 10^9\text{ s}^{-1}} = 0.17\text{ m} = \boxed{17\text{ cm}}$ $\lambda_2 = \frac{c}{f_2} = \frac{3.00 \times 10^8\text{ m/s}}{2.0 \times 10^9\text{ s}^{-1}} = 0.15\text{ m} = \boxed{15\text{ cm}}$
321. $f = 32.0$ cm	You want to appear to be shaking hands with yourself, so the image must appear to be where your hand is. So $p = q$ $\quad\quad \frac{1}{f} = \frac{1}{p} + \frac{1}{q} = \frac{2}{p}$ $p = 2f = (2)(32.0\text{ cm}) = \boxed{64.0\text{ cm}}$ $q = p = \boxed{64.0\text{ cm}}$
322. $p = 5.0$ cm	A car's beam has rays that are parallel, so $q = \infty$. $\frac{1}{q} = \frac{1}{\infty} = 0$ $\quad\quad \frac{1}{f} = \frac{1}{p} + \frac{1}{q} = \frac{1}{p} + 0 = \frac{1}{p}$ $f = p = 5.0$ cm $\frac{2}{R} = \frac{1}{p} + \frac{1}{q} = \frac{1}{f}$ $R = 2f = (2)(5.0\text{ cm}) = \boxed{1.0 \times 10^1\text{ cm}}$
323. $p = 19$ cm $q = 14$ cm	$\frac{1}{f} = \frac{1}{p} + \frac{1}{q} = \frac{1}{19\text{ cm}} + \frac{1}{14\text{ cm}}$ $\frac{1}{f} = \frac{0.053}{1\text{ cm}} + \frac{0.071}{1\text{ cm}} = \frac{0.12}{1\text{ cm}}$ $f = \boxed{8.3\text{ cm}}$
324. $f = -27$ cm $p = 43$ cm	$\frac{1}{q} = \frac{1}{f} - \frac{1}{p} = \frac{1}{-27\text{ cm}} - \frac{1}{43\text{ cm}} = \frac{-0.037}{1\text{ cm}} - \frac{0.023}{1\text{ cm}} = \frac{-0.060}{1\text{ cm}}$ $q = \boxed{-17\text{ cm}}$

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Givens	Solutions
325. $q = -17$ cm $p = 43$ cm	$M = -\frac{q}{p} = -\frac{-17\text{ cm}}{43\text{ cm}} = \boxed{0.40}$
326. $f = -8.2$ cm $p = 18$ cm	$\frac{1}{q} = \frac{1}{f} - \frac{1}{p} = \frac{1}{-8.2\text{ cm}} - \frac{1}{18\text{ cm}} = \frac{-0.122}{1\text{ cm}} - \frac{0.056}{1\text{ cm}} = \frac{-0.18}{1\text{ cm}}$ $q = \boxed{-5.6\text{ cm}}$
327. $f = -39$ cm $p = 16$ cm	$\frac{1}{q} = \frac{1}{f} - \frac{1}{p} = \frac{1}{-39\text{ cm}} - \frac{1}{16\text{ cm}} = \frac{-0.026}{1\text{ cm}} - \frac{0.062}{1\text{ cm}} = \frac{-0.088}{1\text{ cm}}$ $q = \boxed{-11\text{ cm}}$
328. $h = 6.0$ cm	$M = \frac{h'}{h} = -\frac{q}{p}$ $h' = -\frac{qh}{p} = -\frac{(-11\text{ cm})(6.0\text{ cm})}{16\text{ cm}} = \boxed{4.1\text{ cm}}$
329. $f = 1.17306 \times 10^{11}$ Hz $\lambda = 2.5556 \times 10^{-3}$ m	$c = f\lambda = (1.17306 \times 10^{11}\text{ s}^{-1})(2.5556 \times 10^{-3}\text{ m}) = \boxed{2.9979 \times 10^{8}\text{ m/s}}$
330. $f = 2.5 \times 10^{10}$ Hz	$\lambda = \frac{c}{f} = \frac{3.00 \times 10^{8}\text{ m/s}}{2.5 \times 10^{10}\text{ s}^{-1}} = 1.2 \times 10^{-2}\text{ m} = \boxed{1.2\text{ cm}}$
331. $p = 3.00$ cm $= 3.00 \times 10^{2}$ cm $f = 30.0$ cm	$\frac{1}{q} = \frac{1}{f} - \frac{1}{p} = \frac{1}{30.0\text{ cm}} - \frac{1}{3.00 \times 10^{2}\text{ cm}}$ $\frac{1}{q} = \frac{0.0333}{1\text{ cm}} - \frac{0.00333}{1\text{ cm}} = \frac{0.0300}{1\text{ cm}}$ $q = \boxed{33.3\text{ cm}}$
332. $f = -6.3$ cm $q = -5.1$ cm	$\frac{1}{p} = \frac{1}{f} - \frac{1}{q} = \frac{1}{-6.3\text{ cm}} - \frac{1}{-5.1\text{ cm}} = \frac{0.159}{1\text{ cm}} - \frac{0.196}{1\text{ cm}} = \frac{0.037}{1\text{ cm}}$ $p = \boxed{27\text{ cm}}$
333. $p = 27$ cm $q = -5.1$ cm	$M = \frac{-q}{p} = \frac{-(-5.1\text{ cm})}{27\text{ cm}} = \boxed{0.19}$

Refraction

Givens	Solutions
334. $\theta_r = 35°$ $n_r = 1.553$ $n_i = 1.000$	$\theta_i = \sin^{-1}\left[\frac{n_r(\sin\theta_r)}{n_i}\right] = \sin^{-1}\left[\frac{(1.553)(\sin 35°)}{1.000}\right] = \boxed{63°}$

Givens	Solutions
335. $\theta_i = 59.2°$ $n_r = 1.61$ $n_i = 1.00$	$\theta_r = \sin^{-1}\left[\frac{n_i(\sin\theta_i)}{n_r}\right] = \sin^{-1}\left[\frac{(1.00)(\sin 59.2°)}{1.61}\right] = \boxed{32.2°}$
336. $c = 3.00 \times 10^8$ m/s $v = 1.97 \times 10^8$ m/s	$n = \frac{c}{v} = \frac{3.00 \times 10^8 \text{ m/s}}{1.97 \times 10^8 \text{ m/s}} = \boxed{1.52}$
337. $f = -13.0$ cm $M = 5.00$	$M = -\frac{q}{p}$ $q = -Mp = -(5.00)p$ $\frac{1}{f} = \frac{1}{p} + \frac{1}{q} = \frac{1}{p} + \frac{1}{-(5.00)p} = \frac{-5.00 + 1.00}{-(5.00)p} = \frac{-4.00}{-(5.00)p} = \frac{4.00}{(5.00)p}$ $M = \frac{h'}{h} = -\frac{q}{p}$ $p = \frac{(4.00)f}{5.00} = \frac{(4.00)(-13.0\text{ cm})}{5.00} = \boxed{-10.4\text{ cm}}$
338. $h = 18$ cm $h' = -9.0$ cm $f = 6.0$ cm	$M = \frac{h'}{h} = \frac{-9.0\text{ cm}}{18\text{ cm}} = \boxed{-0.50}$
339. $h = 18$ cm $h' = -9.0$ cm $f = 6.0$ cm	$M = -\frac{q}{p}$ $q = -Mp = -(-0.50)p = (0.50)p$ $\frac{1}{f} = \frac{1}{p} + \frac{1}{q} = \frac{1}{p} + \frac{1}{(0.50)p} = \frac{0.50}{(0.50)p} + \frac{1}{(0.50)p} = \frac{1.50}{(0.50)p} = \frac{3.0}{p}$ $p = (3.0)f = (3.0)(6.0\text{ cm}) = \boxed{18\text{ cm}}$
340. $M = -0.50$ $p = 18$ cm	$q = -Mp = (0.50)(18\text{ cm}) = \boxed{9.0\text{ cm}}$
341. $\theta_c = 37.8°$ $n_r = 1.00$	$\sin\theta_c = \frac{n_r}{n_i}$ $n_i = \frac{n_r}{\sin\theta_c} = \frac{1.00}{\sin 37.8°} = \boxed{1.63}$
342. n_i- = 1.766 $n_r = 1.000$	$\sin\theta_c = \frac{n_r}{n_i}$ $\theta_c = \sin^{-1}\left(\frac{n_r}{n_i}\right) = \sin^{-1}\left(\frac{1.000}{1.766}\right) = \boxed{34.49°}$
343. $n_i = 1.576$ $n_r = 1.000$	$\sin\theta_c = \frac{n_r}{n_i}$ $\theta_c = \sin^{-1}\left(\frac{n_r}{n_i}\right) = \sin^{-1}\left(\frac{1.000}{1.576}\right) = \boxed{39.38°}$

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Givens	Solutions
344. $\theta_i = 35.2°$ $n_i = 1.00$ $n_{r,1} = 1.91$ $n_{r,2} = 1.66$	$\theta_{r,1} = \sin^{-1}\left[\frac{n_i(\sin\theta_i)}{n_{r,1}}\right] = \sin^{-1}\left[\frac{(1.00)(\sin 35.2°)}{1.91}\right] = \boxed{17.6°}$ $\theta_{r,2} = \sin^{-1}\left[\frac{n_i(\sin\theta_i)}{n_{r,2}}\right] = \sin^{-1}\left[\frac{(1.00)(\sin 35.2°)}{1.66}\right] = \boxed{20.3°}$
345. $\theta_r = 33°$ $n_r = 1.555$ $n_i = 1.000$	$\theta_i = \sin^{-1}\left[\frac{n_r(\sin\theta_r)}{n_i}\right] = \sin^{-1}\left[\frac{(1.555)(\sin 33°)}{1.000}\right] = \boxed{58°}$
346. $\theta_c = 39.18°$ $n_r = 1.000$	$\sin\theta_c = \frac{n_r}{n_i}$ $n_i = \frac{n_r}{\sin\theta_c} = \frac{1.000}{\sin 39.18} = \boxed{1.583}$
347. $p = 44$ cm $q = -14$ cm $h = 15$ cm	$\frac{1}{f} = \frac{1}{p} + \frac{1}{q} = \frac{1}{44\text{ cm}} + \frac{1}{-14\text{ cm}} = \frac{0.023}{1\text{ cm}} + \frac{0.071}{1\text{ cm}} = \frac{-0.048}{1\text{cm}}$ $f = \boxed{-21\text{ cm}}$
348. $p = 44$ cm $q = -14$ cm $h = 15$ cm	$M = \frac{h'}{h} = -\frac{q}{p}$ $h' = -\frac{qh}{p} = -\frac{(-14\text{ cm})(15\text{ cm})}{44\text{ cm}} = \boxed{4.8\text{ cm}}$
349. $p = 4$ m $f = 4$ m	$\frac{1}{f} = \frac{1}{p} + \frac{1}{q}$, but $f = p$, so $\frac{1}{q} = 0$. That means $q = \boxed{\infty}$
350. $p = 4$ m $f = 4$ m	$M = -\frac{q}{p} = -\frac{\infty}{4\text{ m}} = \boxed{\infty}$ The rays are parallel, and the light can be seen from very far away.
351. $n_i = 1.670$ $\theta_c = 62.85°$	$\sin\theta_c = \frac{n_r}{n_i}$ $n_r = n_i(\sin\theta_c) = (1.670)(\sin 62.85°) = \boxed{1.486}$
352. $c = 3.00 \times 10^8$ m/s $v = 2.07 \times 10^8$ m/s	$n = \frac{c}{v} = \frac{3.00 \times 10^8\text{ m/s}}{2.07 \times 10^8\text{ m/s}} = \boxed{1.45}$
353. $c = 3.00 \times 10^8$ m/s $v = 1.95 \times 10^8$ m/s	$n = \frac{c}{v} = \frac{3.00 \times 10^8\text{ m/s}}{1.95 \times 10^8\text{ m/s}} = \boxed{1.54}$
354. $p = 0.5$ m $f = 0.5$ m	$\frac{1}{f} = \frac{1}{p} + \frac{1}{q}$ $p = f$, so $\frac{1}{q} = 0$, and $q = \boxed{\infty}$

Givens	*Solutions*
355. $f = 3.6$ cm $q = 15.2$ cm	$\frac{1}{p} = \frac{1}{f} - \frac{1}{q} = \frac{1}{3.6\text{ cm}} - \frac{1}{15.2\text{ cm}} = \frac{0.28}{1\text{ cm}} - \frac{0.066}{1\text{ cm}} = \frac{0.21}{1\text{ cm}}$ $p = \boxed{4.8\text{ cm}}$
356. $q = -12$ cm $f = -44$ cm	$\frac{1}{p} = \frac{1}{f} - \frac{1}{q} = \frac{1}{-44\text{ cm}} - \frac{1}{-12\text{ cm}} = \left(\frac{-0.023}{1\text{ cm}}\right) - \left(\frac{-0.083}{1\text{ cm}}\right) = \frac{0.060}{1\text{ cm}}$ $p = \boxed{17\text{ cm}}$
357. $\theta_{c,1} = 35.3°$ $\theta_{c,2} = 33.1°$ $n_r = 1.00$	$\sin\theta_c = \frac{n_r}{n_i}$ $n_{i,1} = \frac{n_r}{\sin\theta_{c,1}} = \frac{1.00}{\sin 35.3°} = \boxed{1.73}$ $n_{i,2} = \frac{n_r}{\sin\theta_{c,2}} = \frac{1.00}{\sin 33.1°} = \boxed{1.83}$
358. $n_i = 1.64$ $\theta_c = 69.9°$	$\sin\theta_c = \frac{n_r}{n_i}$ $n_r = n_i(\sin\theta_c) = (1.64)(\sin 69.9°) = \boxed{1.54}$

Interference and Diffraction

Givens	*Solutions*
359. $\lambda = 5.875 \times 10^{-7}$ m $m = 2$ $\theta = 0.130°$	$d = \frac{m\lambda}{\sin\theta} = \frac{2(5.875 \times 10^{-7}\text{ m})}{\sin(0.130°)} = 5.18 \times 10^{-4}$ m $d = \boxed{0.518\text{ mm}}$
360. $d = 8.04 \times 10^{-6}$ m $m = 3$ $\theta = 13.1°$	$\lambda = \frac{d(\sin\theta)}{m} = \frac{(8.04 \times 10^{-6}\text{ m})\sin(13.1°)}{3} = 6.07 \times 10^{-7}$ m $\lambda = \boxed{607\text{ nm}}$
361. $d = 2.20 \times 10^{-4}$ m $\lambda = 5.27 \times 10^{-7}$ m $m = 1$	$\theta = \sin^{-1}(m\lambda/d)$ $\theta = \sin^{-1}[(1)(5.27 \times 10^{-7}\text{ m}) \div (2.20 \times 10^{-4}\text{ m})] = \boxed{0.137°}$
362. $\lambda = 5.461 \times 10^{-7}$ m $m = 1$ $\theta = 75.76°$	$d = \frac{m\lambda}{\sin\theta} = \frac{(1)(5.461 \times 10^{-7}\text{ m})}{\sin(75.76°)} = 5.634 \times 10^{-7}$ m $d = 5.634 \times 10^{-5}$ cm # lines/cm = $(5.634 \times 10^{-5}\text{ cm})^{-1} = \boxed{1.775 \times 10^4\text{ lines/cm}}$
363. 3600 lines/cm $m = 3$ $\theta = 76.54°$	$\lambda = \frac{d(\sin\theta)}{m} = \frac{(360\,000\text{ m})^{-1}\sin(76.54°)}{3} = \boxed{9.0 \times 10^{-7} = 9.0 \times 10^2\text{ nm}}$

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Givens	Solutions
364. 1950 lines/cm $\lambda = 4.973 \times 10^{-7}$ m $m = 1$	$m = 1$: $\theta_1 = \sin^{-1}(m\lambda/d)$ $\theta_1 = \sin^{-1}[(1)(4.973 \times 10^{-7}\text{ m}) \div (195\,000\text{ lines/m})^{-1}]$ $\theta_1 = \boxed{5.56°}$
365. 1950 lines/cm $\lambda = 4.973 \times 10^{-7}$ m $m = 2$	$m = 1$: $\theta_1 = \sin^{-1}(m\lambda/d)$ $m = 2$: $\theta_2 = \sin^{-1}[(2)(4.973 \times 10^{-7}\text{ m}) \div (195\,000\text{ lines/m})^{-1}]$ $\theta_2 = \boxed{11.2°}$
366. $d = 3.92 \times 10^{-6}$ m $m = 2$ $\theta = 13.1°$	$\lambda = \frac{d(\sin\theta)}{m} = \frac{(3.92 \times 10^{-6}\text{ m})\sin(13.1°)}{2} = 4.44 \times 10^{-7}\text{ m}$ $\lambda = \boxed{444\text{ nm}}$
367. $\lambda = 430.8$ nm $d = 0.163$ mm $m = 1$	$\theta = \sin^{-1}\frac{\left(m + \frac{1}{2}\right)\lambda}{d} = \sin^{-1}\frac{\left(1 + \frac{1}{2}\right)(430.8 \times 10^{-9}\text{ nm})}{0.163 \times 10^{-3}\text{ m}}$ $\theta = \sin^{-1} 0.00396 = \boxed{0.227°}$
368. $\lambda = 656.3$ nm $m = 3$ $\theta = 0.548°$	$d = \frac{\left(m + \frac{1}{2}\right)\lambda}{\sin\theta} = \frac{\left(3 + \frac{1}{2}\right)(656.3 \times 10^{-9}\text{ m})}{\sin 0.548°}$ $d = \boxed{2.40 \times ^{-4}\text{ m} = 0.240\text{ mm}}$
369. $\lambda = 4.471 \times 10^{-7}$ m $m = 1$ $\theta = 40.25°$	$d = \frac{m\lambda}{\sin\theta} = \frac{(1)(4.471 \times 10^{-7}\text{ m})}{\sin(40.25°)} = 6.920 \times 10^{-7}\text{ m}$ $d = 6.920 \times 10^{-7}$ cm # lines/cm = $(6.920 \times 10^{-7}\text{ cm})^{-1} = \boxed{1.445 \times 10^4\text{ lines/cm}}$
370. 9550 lines/cm $m = 2$ $\theta = 54.58°$	$\lambda = \frac{d(\sin\theta)}{m} = \frac{(955\,000\text{ m})^{-1}\sin(54.58°)}{2} = \boxed{4.27 \times 10^{-7}\text{ m} = 427\text{ nm}}$

Electric Forces and Fields

371. $q_1 = -5.3\ \mu\text{C} = -5.3 \times 10^{-6}$ C $q_2 = +5.3\ \mu\text{C} = 5.3 \times 10^{-6}$ C $r = 4.2\text{ cm} = 4.2 \times 10^{-2}$ m $k_C = 8.99 \times 10^9\ \text{N}\bullet\text{m}^2/\text{C}^2$	$F_{electric} = \frac{k_C q_1 q_2}{r^2}$ $F_{electric} = \frac{(8.99 \times 10^9\ \text{N}\bullet\text{m}^2/\text{C}^2)(5.3 \times 10^{-6}\text{ C})^2}{(4.2 \times 10^{-2}\text{ m})^2}$ $F_{electric} = \boxed{140\text{ N attractive}}$

Givens	Solutions
372. $q_1 = -8.0 \times 10^{-9}$ C $q_2 = +8.0 \times 10^{-9}$ C $r = 2.0 \times 10^{-2}$ m $k_C = 8.99 \times 10^9$ N•m²/C²	$F_{electric} = \dfrac{k_C q_1 q_2}{r^2}$ $F_{electric} = \dfrac{(8.99 \times 10^9 \text{ N•m}^2/\text{C}^2)(-8.0 \times 10^{-9}\text{ C})(8.0 \times 10^{-9}\text{ C})}{(2.0 \times 10^{-2}\text{ m})^2}$ $F_{electric} = \boxed{1.4 \times 10^{-3}\text{ N}}$
373. $r = 6.5 \times 10^{-11}$ m $F_{electric} = 9.92 \times 10^{-4}$ N $k_C = 8.99 \times 10^9$ N•m²/C²	$F_{electric} = \dfrac{k_C q_1 q_2}{r^2} = \dfrac{k_C q^2}{r^2}$ $q = \sqrt{\dfrac{F_{electric} r^2}{k_C}} = \sqrt{\dfrac{(9.92 \times 10^{-4}\text{ N})(6.5 \times 10^{-11}\text{ m})^2}{8.99 \times 10^9 \text{ N•m}^2/\text{C}^2}}$ $q = \boxed{2.2 \times 10^{-17}\text{ C}}$
374. $q_1 = -1.30 \times 10^{-5}$ C $q_2 = -1.60 \times 10^{-5}$ C $F_{electric} = 12.5$ N $k_C = 8.99 \times 10^9$ N•m²/C²	$F_{electric} = \dfrac{k_C q_1 q_2}{r^2}$ $r = \sqrt{\dfrac{k_C q_1 q_2}{F_{electric}}} = \sqrt{\dfrac{(8.99 \times 10^9 \text{ N•m}^2/\text{C}^2)(-1.30 \times 10^{-5}\text{ C})(-1.60 \times 10^{-5}\text{ C})}{12.5\text{ N}}}$ $r = 0.387\text{ m} = \boxed{38.7\text{ cm}}$
375. $q_1 = q_2 = q_3 = 4.00 \times 10^{-9}$ C $k_C = 8.99 \times 10^9$ N•m²/C² $r_{2,1} = r_{2,3} = 4.00$ m	$F_{12} = \dfrac{k_C q_1 q_2}{r^2} = (8.99 \times 10^9 \text{ N•m}^2/\text{C}^2)\dfrac{(4.00 \times 10^{-9}\text{ C})^2}{(4.00\text{ m})^2}$ $F_{12} = 5.99 \times 10^{-9}$ N to the right, $F_{12} = 5.99 \times 10^{-9}$ N $F_{23} = k_C \dfrac{q_2 q_3}{r^2} = (8.99 \times 10^9 \text{ N•m}^2/\text{C}^2)\dfrac{(4.00 \times 10^{-9}\text{ C})^2}{(4.00\text{ m})^2}$ $F_{12} = 5.99 \times 10^{-9}$ N to the left, $F_{23} = -5.99 \times 10^{-9}$ N $F_{net} = F_{12} + F_{23} = 5.99 \times 10^{-9}\text{ N} - 5.99 \times 10^{-9}\text{ N} = \boxed{0.00\text{ N}}$
376. $q_p = 1.60 \times 10^{-19}$ C $r_{4,1} = r_{2,1} = 1.52 \times 10^{-9}$ m $k_C = 8.99 \times 10^9$ N•m²/C²	$q_p = q_1 = q_2 = q_3 = q_4$ $r_{3,2} = \sqrt{(1.52 \times 10^{-9}\text{ m})^2 + (1.52 \times 10^{-9}\text{ m})^2} = 2.15 \times 10^{-9}$ m $F_{2,1} = \dfrac{k_C q_p^2}{r_{2,1}^2} = \dfrac{(8.99 \times 10^9 \text{ N•m}^2/\text{C}^2)(1.60 \times 10^{-19}\text{ C})^2}{(1.52 \times 10^{-9}\text{ m})^2} = 9.96 \times 10^{-11}$ N $F_{3,1} = \dfrac{k_C q_p^2}{r_{3,1}^2} = \dfrac{(8.99 \times 10^9 \text{ N•m}^2/\text{C}^2)(1.60 \times 10^{-19}\text{ C})^2}{(2.15 \times 10^{-9}\text{ m})^2} = 4.98 \times 10^{-11}$ N $F_{4,1} = \dfrac{k_C q^2_p}{r_{4,1}^2} = \dfrac{(8.99 \times 10^9 \text{ N•m}^2/\text{C}^2)(1.60 \times 10^{-19}\text{ C})^2}{(1.52 \times 10^{-9}\text{ m})^2} = 9.96 \times 10^{-11}$ N $\varphi = \tan^{-1}\left(\dfrac{1.52 \times 10^{-9}\text{ m}}{1.52 \times 10^{-9}\text{ m}}\right) = 45°$ $F_{2,1}$: $F_x = 0$ N $F_y = 9.96 \times 10^{-11}$ N $F_{3,1}$: $F_x = F_{3,1} \cos 45° = (4.98 \times 10^{-11}\text{ N})(\cos 45°) = 3.52 \times 10^{-11}$ N $F_y = F_{3,1} \sin 45° = (4.98 \times 10^{-11}\text{ N})(\sin 45°) = 3.52 \times 10^{-11}$ N $F_{4,1}$: $F_x = 9.96 \times 10^{-11}$ N $F_y = 0$ N

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Givens	Solutions

$F_{x,tot} = 0\text{ N} + 3.52 \times 10^{-11} + 9.96 \times 10^{-11} = 1.35 \times 10^{-10}\text{ N}$

$F_{y,tot} = 9.96 \times 10^{-10}\text{ N} + 3.52 \times 10^{-11}\text{ N} + 0\text{ N} = 1.35 \times 10^{-10}\text{ N}$

$F_{tot} = \sqrt{(F_{x,tot})^2 + (F_{y,tot})^2} = \sqrt{(1.35 \times 10^{-10}\text{ N})^2 + (1.35 \times 10^{-10}\text{ N})^2}$

$F_{tot} = \boxed{1.91 \times 10^{-10}\text{ N}}$

$\varphi = \tan^{-1}\left(\frac{1.35 \times 10^{-10}\text{ N}}{1.35 \times 10^{-10}\text{ N}}\right) = \boxed{45.0°}$

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377. $q_1 = q_2 = q_3 = 2.0 \times 10^{-9}\text{ C}$

$r_{1,2} = 1.0\text{ m}$

$r_{1,3} = \sqrt{(1.0\text{ m})^2 + (2.0\text{ m})^2} = 2.24\text{ m}$

$k_C = 8.99 \times 10^9\text{ N•m}^2/\text{C}^2$

$F_{12} = \frac{k_C q_1 q_2}{r_{12}^2} = \frac{(8.99 \times 10^9\text{ N•m}^2/\text{C}^2)(2.0 \times 10^{-9}\text{ C})^2}{(1.0\text{ m})^2} = 3.6 \times 10^{-8}\text{ N}$

Components of F_{12}: $F_{12,x} = 3.6 \times 10^{-8}\text{ N}$

$F_{12,y} = 0\text{ N}$

$F_{13} = \frac{k_C q_1 q_3}{r_{13}^2} = \frac{(8.99 \times 10^9\text{ N•m}^2/\text{C}^2)(2.0 \times 10^{-9}\text{ C})^2}{(2.24\text{ m})^2} = 7.2 \times 10^{-8}\text{ N}$

$\varphi_{13} = \tan^{-1}\left(\frac{2.0\text{ m}}{1.0\text{ m}}\right) = 63°$

Components of F_{13}:

$F_{13,x} = F_{13}\cos\theta = (7.2 \times 10^{-9}\text{ N})\cos(63.4°) = 3.2 \times 10^{-9}\text{ N}$

$F_{13,y} = F_{13}\sin\theta = (7.2 \times 10^{-9}\text{ N})\sin(63.4°) = 6.4 \times 10^{-9}\text{ N}$

$F_{x,tot} = F_{12,x} + F_{13,x} = 7.2 \times 10^{-8}\text{ N} + 3.2 \times 10^{-9}\text{ N} = 3.9 \times 10^{-8}\text{ N}$

$F_{y,tot} = F_{12,y} + F_{13,y} = 0\text{ N} + 6.4 \times 10^{-9}\text{ N} = 6.4 \times 10^{-9}\text{ N}$

$F_{tot} = \sqrt{(F_{x,tot})^2 + (F_{y,tot})^2} = \sqrt{(3.9 \times 10^{-8}\text{ N})^2 + (6.4 \times 10^{-9}\text{ N})^2}$

$F_{tot} = \boxed{4.0 \times 10^{-8}\text{ N}}$

$\varphi = \tan^{-1}\left(\frac{F_{y.tot}}{F_{x.tot}}\right) = \tan^{-1}\left(\frac{6.4 \times 10^{-9}\text{ N}}{3.9 \times 10^{-8}\text{ N}}\right) = \boxed{9.3°}$

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378. $q_1 = 7.2\text{ nC}$

$q_2 = 6.7\text{ nC}$

$q_3 = -3.0\text{ nC}$

$k_C = 8.99 \times 10^9\text{ N•m}^2/\text{C}^2$

$r_{1,2} = 3.2 \times 10^{-1}\text{ m} = 0.32\text{ m}$

The charge, q_3, must be between the charges to achieve electrostatic equilibrium.

$F_{1,3} + F_{1,2} = \frac{k_C q_1 q_3}{x^2} - \frac{k_C q_2 q_3}{(x - 0.32\text{ m})^2} = 0$

$(q_1 - q_2)x^2 - (0.64\text{ m})q_1 x + (0.32\text{ m})^2 q_1 x = 0$

$x = \frac{(0.64\text{ m})(7.2\text{ nC}) \pm \sqrt{(0.64\text{ m})^2(7.2\text{ nC})^2 - 4(7.2\text{ nC} - 6.7\text{ nC})(0.32\text{ m})^2(7.2\text{ nC})}}{2(7.2\text{ nC} - 6.7\text{ nC})}$

$x = \boxed{16\text{ cm}}$

Givens	Solutions
379. $q_1 = 6.0\ \mu C$ $q_2 = -12.0\ \mu C$ $q_3 = 6.0\ \mu C$ $k_C = 8.99 \times 10^9\ N\bullet m^2/C^2$ $r_{1,0} = 5.0 \times 10^{-2}\ m$	$F_{2,3} = -F_{1,2} = \frac{-k_C q_1 q_2}{r_{1,2}^2} = \frac{-(8.99 \times 10^9\ N\bullet m^2/C^2)(6.0 \times 10^{-6}\ C)(-12.0 \times 10^{-6}\ C)}{(5.0 \times 10^{-2}\ m)^2}$ $F_{2,3} = \boxed{260\ N}$
380. $E_x = 9.0\ N/C$ $q = -6.0\ C$	$E_x = \frac{F_{electric}}{q}$ $F_{electric} = E_x q = (9.0\ N/C)(-6.0\ C)$ $F_{electric} = \boxed{-54\ N \text{ in the } -x \text{ direction}}$
381. $E = 4.0 \times 10^3\ N/C$ $F_{electric} = 6.43 \times 10^{-9}\ N$	$E = \frac{F_{electric}}{q}$ $q = \frac{F_{electric}}{E} = \frac{6.43 \times 10^{-9}\ N}{4.0 \times 10^3\ N/C} = \boxed{1.6 \times 10^{-12}\ C}$
382. $q_1 = 1.50 \times 10^{-5}\ C$ $q_2 = 5.00 \times 10^{-6}\ C$ $k_C = 8.99 \times 10^9\ N\bullet m^2/C^2$ $r_1 = 1.00\ m$ $r_2 = 0.500\ m$	$E_1 = E_{y,1} = \frac{k_C q_1}{r_1^2} = \frac{(8.99 \times 10^9\ N\bullet m^2/C^2)(1.50 \times 10^{-5}\ C)}{(1.00\ m)^2} = 1.35 \times 10^5\ N/C$ $E_2 = E_{y,2} = \frac{k_C q_2}{r_2^2} = \frac{(8.99 \times 10^9\ N\bullet m^2/C^2)(5.00 \times 10^{-6}\ C)}{(0.500\ m)^2} = 1.80 \times 10^5\ N/C$ $E_{y,tot} = E_{tot} = 1.35 \times 10^5\ N/C + 1.80 \times 10^5\ N/C = \boxed{3.15 \times 10^5\ N/C}$ The electric field points along the y-axis.
383. $q_1 = 9.99 \times 10^{-5}\ C$ $q_2 = 3.33 \times 10^{-5}\ C$ $F_{electric} = 87.3\ N$ $k_C = 8.99 \times 10^9\ N\bullet m^2/C^2$	$F_{electric} = \frac{k_C q_1 q_2}{r^2}$ $r = \sqrt{\frac{k_C q_1 q_2}{F_{electric}}} = \sqrt{\frac{(8.99 \times 10^9\ N\bullet m^2/C^2)(9.99 \times 10^{-5}\ C)(3.33 \times 10^{-5}\ C)^1}{87.3\ N}}$ $r = 0.585\ m = \boxed{58.5\ cm}$
384. $r = 9.30 \times 10^{-11}\ m$ $F_{electric} = 2.66 \times 10^{-8}\ N$ $k_C = 8.99 \times 10^9\ N\bullet m^2/C^2$	$F_{electric} = \frac{k_C q_1 q_2}{r^2} = \frac{k_C q^2}{r^2}$ $q = \sqrt{\frac{F_{electric} r^2}{k_C}} = \sqrt{\frac{(2.66 \times 10^{-8}\ N)(9.30 \times 10^{-11}\ m)^2}{8.99 \times 10^9\ N\bullet m^2/C^2}}$ $q = \boxed{1.60 \times 10^{-19}\ C}$

Givens | *Solutions*

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385. $q_1 = -2.34 \times 10^{-8}$ C

$q_2 = 4.65 \times 10^{-9}$ C

$q_3 = 2.99 \times 10^{-10}$ C

$r_{1,2} = 0.500$ m

$r_{1,3} = 1.00$ m

$k_C = 8.99 \times 10^9$ N•m²/C²

$$F_{1,2} = \frac{k_C q_1 q_2}{{r_{1,2}}^2} = \frac{(8.99 \times 10^9 \text{ N•m}^2/\text{C}^2)(-2.34 \times 10^{-8}\text{ C})(4.65 \times 10^{-9}\text{ C})}{(0.500\text{ m})^2}$$

$$F_{1,2} = F_y = -3.91 \times 10^{-6}\text{ N}$$

$$F_{1,3} = \frac{k_C q_1 q_3}{{r_{1,3}}^2} = \frac{(8.99 \times 10^9 \text{ N•m}^2/\text{C}^2)(-2.34 \times 10^{-8}\text{ C})(2.99 \times 10^{-10}\text{ C})}{(1.00\text{ m})^2}$$

$$F_{1,3} = F_y = -6.29 \times 10^{-8}\text{ N}$$

$$F_{y,tot} = -3.91 \times 10^{-6}\text{ N} + -6.29 \times 10^{-8}\text{ N} = 3.97 \times 10^{-6}\text{ N}$$

There are no x-components of the electrical force, so the magnitude of the electrical force is $\sqrt{(F_{y,tot})^2}$.

$$F_{tot} = \boxed{3.97 \times 10^{-6}\text{ N upward}}$$

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386. $q_1 = -9.00 \times 10^{-9}$ C

$q_2 = -8.00 \times 10^{-9}$ C

$q_3 = 7.00 \times 10^{-9}$ C

$r_{1,2} = 2.00$ m

$r_{1,3} = 3.00$ m

$k_C = 8.99 \times 10^9$ N•m²/C²

$$F_{1,2} = \frac{k_C q_1 q_2}{{r_{1,2}}^2} = \frac{(8.99 \times 10^9 \text{ N•m}^2/\text{C}^2)(-9.00 \times 10^{-9}\text{ C})(-8.00 \times 10^{-9}\text{ C})}{(2.00\text{ m})^2} = 1.62 \times 10^{-7}\text{ N}$$

$$F_{1,3} = \frac{k_C q_1 q_3}{{r_{1,3}}^2} = \frac{(8.99 \times 10^9 \text{ N•m}^2/\text{C}^2)(-9.00 \times 10^{-9}\text{ C})(-7.00 \times 10^{-9}\text{ C})}{(3.00\text{ m})^2} = -6.29 \times 10^{-8}\text{ N}$$

$F_{1,2}$: $F_x = 4.05 \times 10^{-8}$ N

$F_y = 0$ N

$F_{1,3}$: $F_x = 0$ N

$F_y = -6.29 \times 10^{-8}$ N

$$F_{tot} = \sqrt{(1.62 \times 10^{-7}\text{ N})^2 + (-6.29 \times 10^{-8}\text{ N})^2} = \boxed{1.74 \times 10^{-7}\text{ N}}$$

F_{tot} is negative because the larger, y-component of the force is negative.

$$\varphi = \tan^{-1}\left(\frac{-6.29 \times 10^{-8}\text{ N}}{1.62 \times 10^{-7}\text{ N}}\right) = \boxed{-21.2°}$$

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387. $q_1 = -2.5$ nC

$q_2 = -7.5$ nC

$q_3 = 5.0$ nC

$k_C = 8.99 \times 10^9$ N•m²/C²

$r_{1,2} = 20.0$ cm

The charge, q_3, must be between the charges to achieve electrostatic equilibrium.

$$F_{1,3} + F_{1,2} = \frac{k_C q_1 q_3}{x^2} - \frac{k_C q_2 q_3}{(x - 20.0\text{ cm})^2} = 0$$

$$(q_1 - q_2)x^2 - (40.0\text{ cm})q_1 x + (20.0\text{ cm})^2 q_1 x = 0$$

$$x = \frac{(40.0\text{ cm})(-2.5\text{ nC}) \pm \sqrt{(40.0\text{ cm})^2(-2.5\text{ nC})^2 - 4(-2.5\text{ nC} + 7.5\text{ nC})(20.0\text{ cm})^2(-2.5\text{ nC})}}{2(-2.5\text{ nC} + 7.5\text{ nC})}$$

$$x = \boxed{7.3\text{ cm}}$$

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388. $q_1 = -2.3$ C

$q_3 = -4.6$ C

$r_{1,2} = r_{3,1} = 2.0$ m

$r_{3,2} = 4.0$ m

$k_C = 8.99 \times 10^9$ N•m²/C²

$$F_{3,1} + F_{3,2} = \frac{-k_C q_3 q_1}{{r_{3,1}}^2} - \frac{k_C q_3 q_2}{r_{3,2}} = 0$$

$$q_2 = \frac{-q_1 {r_{3,2}}^2{}_2}{r_{3,1}} = \frac{-(-2.3\text{ C})(4.0\text{ m})^2}{(2.0\text{ m})^2} = \boxed{9.2\text{ C}}$$

Givens	Solutions
389. $E_y = 1500$ N/C $q = 5.0 \times 10^{-9}$ C	$E_y = \dfrac{F_{electric}}{q}$ $F_{electric} = E_y q = (1500 \text{ N/C})(5.0 \times 10^{-9} \text{ C})$ $F_{electric} = \boxed{7.5 \times 10^{-6} \text{ N in the } +y \text{ direction}}$
390. $E = 1663$ N/C $F_{electric} = 8.4 \times 10^{-9}$ N	$E = \dfrac{F_{electric}}{q}$ $q = \dfrac{F_{electric}}{E} = \dfrac{8.42 \times 10^{-9} \text{ N}}{1663 \text{ N/C}} = \boxed{5.06 \times 10^{-12} \text{ C}}$
391. $q_q = 3.00 \times 10^{-6}$ C $q_2 = 3.00 \times 10^{-6}$ C $k_C = 8.99 \times 10^9$ N•m^2/C^2 $r_1 = 0.250$ m	$r_2 = \sqrt{(2.00 \text{ m})^2 + (2.00 \text{ m})^2} = 2.02$ m $E_1 = E_y = E_y = \dfrac{k_C q_1}{r_1^2} = \dfrac{(8.99 \times 10^9 \text{ N•m}^2/\text{C}^2)(3.00 \times 10^{-6} \text{ C})}{(0.250 \text{ m})^2}$ $E_1 = E_{y,1} = 4.32 \times 10^5$ N/C $E_2 = \dfrac{k_C q_2}{r_2^2} = \dfrac{(8.99 \times 10^9 \text{ N•m}^2/\text{C}^2)(3.00 \times 10^{-6} \text{ C})}{(2.02 \text{ m})^2} = 6.61 \times 10^3$ N/C $\varphi = \tan^{-1}\left(\dfrac{y}{x}\right) = \tan^{-1}\left(\dfrac{0.250 \text{ m}}{2.00 \text{ m}}\right) = 7.12°$ $E_{x,2} = E_2 \cos 7.12° = (6.61 \times 10^3 \text{ N/C})(\cos 7.12°) = 6.56 \times 10^3$ N/C $E_{y,2} = E_2 \sin 7.12° = (6.61 \times 10^3 \text{ N/C})(\sin 7.12°) = 8.19 \times 10^3$ N/C $E_{x,tot} = 0 \text{ N/C} + 6.56 \times 10^3 \text{ N/C} = 6.56 \times 10^3$ N/C $E_{y,tot} = 4.32 \times 10^5 \text{ N/C} + 8.19 \times 10^3 \text{ N/C} = 4.40 \times 10^5$ N/C $E_{tot} = \sqrt{(E_{x,tot}{}^2 + (E_{y,tot})^2}$ $E_{tot} = \sqrt{(6.56 \times 10^3 \text{ N/C})^2 + (4.40 \times 10^5 \text{ N/C})^2}$ $E_{tot} = \boxed{4.40 \times 10^5 \text{ N/C}}$ $\tan \varphi = \dfrac{E_{y,tot}}{E_{x,tot}} = \dfrac{4.40 \times 10^5 \text{ N/C}}{6.56 \times 10^3 \text{ N/C}}$ $\varphi = \boxed{89.1°}$
392. $q_1 = -1.6 \times 10^{-19}$ C $k_C = 8.99 \times 10^9$ N•m^2/C^2 $q_2 = -1.60 \times 10^{-19}$ C $q_3 = 1.60 \times 10^{-19}$ C $r_1 = 3.00 \times 10^{-10}$ m $r_2 = 2.00 \times 10^{-10}$ m	$F_{x,tot} = \dfrac{k_C q_1}{r^2} + \dfrac{k_C q_2}{r_2^2} + \dfrac{k_C q_3}{x^2} = 0$ $q_1 = q_2 = -q_3$ $k_C q_1 \left(\dfrac{1}{r_1^2} + \dfrac{1}{r_2^2} - \dfrac{1}{x^2}\right) = 0$ $k_C q_1 \left(\dfrac{1}{r_1^2} + \dfrac{1}{r_2^2}\right) = \dfrac{k_C q_1}{x^2}$ $x^2 = \dfrac{1}{\dfrac{1}{r_1^2} + \dfrac{1}{r_2^2}} = \dfrac{1}{\dfrac{1}{(3.00 \times 10^{-10} \text{ m})^2} + \dfrac{1}{(2.00 \times 10^{-10} \text{ m})}}$ $x = \boxed{1.66 \times 10^{-10} \text{ m}}$

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Givens / *Solutions*

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393. $q_1 = -7.0$ C

$x_1 = 0$

$q_2 = 49$ C

$x_2 = 18$ m

$x_3 = 25$ m

To remain in equilibrium, the force on q_2 by q_1 (F_{21}, which is in the negative direction) must equal the force on q_2 by q_3 (F_{23}, which must be in the positive direction).

$$-\frac{k_C q_2 q_1}{r_{12}^2} = \frac{k_C q_2 q_3}{r_{23}^2}$$

$$-\frac{q_2}{r_{12}^2} = \frac{q_3}{r_{23}^2}$$

$$q_3 = -q_2\frac{r_{23}^2}{r_{12}^2} = -(49\text{ C})\left(\frac{(25\text{ m} - 18\text{ m})^2}{(18\text{ m} - 0\text{ m})^2}\right) = \boxed{-7.4\text{ C}}$$

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394. $r = 8.3 \times 10^{-10}$ m

$F_{electric} = 3.34 \times 10^{-10}$ N

$k_C = 8.99 \times 10^9$ N•m^2/C^2

$$F_{electric} = \frac{k_C q_1 q_2}{r^2} = \frac{k_C q^2}{r^2}$$

$$q = \sqrt{\frac{F_{electric} r^2}{k_C}} = \sqrt{\frac{(3.34 \times 10^{-10}\text{ N})(8.3 \times 10^{-10}\text{ N})^2}{8.99 \times 10^9\text{ N•m}^2/\text{C}^2}}$$

$$q = \boxed{1.6 \times 10^{-19}\text{ C}}$$

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395. $r = 6.4 \times 10^{-8}$ m

$F_{electric} = 5.62 \times 10^{-14}$ N

$k_C = 8.99 \times 10^9$ N•m^2/C^2

$$F_{electric} = \frac{k_C q_1 q_2}{r^2} = \frac{k_C q_2}{r^2}$$

$$q = \sqrt{\frac{F_{electric} r^2}{k_C}} = \sqrt{\frac{(5.62 \times 10^{-14}\text{ N})(6.4 \times 10^{-8}\text{ m})^2}{8.99 \times 10^9\text{ N•m}^2\text{C}^2}}$$

$$q = \boxed{1.6 \times 10^{-19}\text{ C}}$$

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396. $q_e = -1.60 \times 10^{-19}$ C

$r_{2,3} = r_{4,3} = 3.02 \times 10^{-5}$ m

$r_{1,3} = \sqrt{2(3.02 \times 10^{-5}\text{ m})^2}$
$= 4.27 \times 10^{-5}$ m

$k_C = 8.99 \times 10^9$ N•m^2/C^2

$$q_e = q_1 = q_2 = q_3 = q_4$$

$$F_{3,2} = F_x = \frac{k_C q_2 e}{r_{3,2}^2} = \frac{(8.99 \times 10^9\text{ N•m}^2/\text{C}^2)(-1.60 \times 10^{-19}\text{ C})^2}{(3.02 \times 10^{-5}\text{ m})^2} = 2.52 \times 10^{-19}\text{ N}$$

$$F_{3,4} = F_y = \frac{k_C q e^2}{r_{3,4}^2} = \frac{(8.99 \times 10^9\text{ N•m}^2/\text{C}^2)(-1.60 \times 10^{-19}\text{ C})^2}{(3.02 \times 10^{-5}\text{ m})^2} = 2.52 \times 10^{-19}\text{ N}$$

$$F_{3,1} = \frac{k_C q_e^2}{r_{3,1}^2} = \frac{(8.99 \times 10^9\text{ N•m}^2/\text{C}^2)(-1.60 \times 10^{-19}\text{ C})^2}{(4.27 \times 10^{-5}\text{ m})^2} = 1.26 \times 10^{-19}\text{ N}$$

$$\varphi = \tan^{-1}\left(\frac{3.02 \times 10^{-5}\text{ m}}{3.02 \times 10^{-5}\text{ m}}\right) = 45°$$

$F_{3,1}$: $F_x = F_{3,1}\cos 45° = (1.26 \times 10^{-19}\text{ N})\cos 45° = 8.91 \times 10^{-20}$ N

$F_y = F_{3,1}\sin 45° = (1.26 \times 10^{-19}\text{ N})\sin 45° = 8.91 \times 10^{-20}$ N

$$F_{x,tot} = 8.91 \times 10^{-20}\text{ N} + 2.52 \times 10^{-19}\text{ N} + 0\text{ N} = 3.41 \times 10^{-19}\text{ N}$$

$$F_{y,tot} = 8.91 \times 10^{-20}\text{ N} + 0\text{ N} + 2.52 \times 10^{-19}\text{ N} = 3.41 \times 10^{-19}\text{ N}$$

$$F_{tot} = \sqrt{(F_{x,tot})^2 + (F_{y,tot})^2} = \sqrt{(3.41 \times 10^{-19}\text{ N})^2\ (3.41 \times 10^{-19}\text{ N})^2}$$

$$F_{tot} = \boxed{4.82 \times 10^{-19}\text{ N}}$$

$$\varphi = \tan^{-1}\left(\frac{F_{y,tot}}{F_{x,tot}}\right) = \tan^{-1}\left(\frac{3.41 \times 10^{-19}\text{ N}}{3.41 \times 10^{-19}\text{ N}}\right) = \boxed{45°}$$

Givens	*Solutions*
397. $q_1 = 5.5$ nC $q_2 = 11$ nC $q_3 = -22$ nC $k_C = 8.99 \times 10^9$ N•m²/C² → $k_C = 8.99 \times 10^9 \text{ N•m}^2/\text{C}^2$ $r_{1,2} = 88$ cm	The charge, q_3, must be between the charges to achieve electrostatic equilibrium. $F_{1,3} + F_{1,2} = \frac{k_C q_1 q_3}{x^2} - \frac{k_C q_2 q_3}{(x - 88\text{ cm})^2} = 0$ $(q_1 - q_2)x^2 - (176\text{ cm})q_1 x + (88\text{ cm})^2 q_1 x = 0$ $x = \frac{(176\text{ cm})(5.5\text{ nC}) \pm \sqrt{(176\text{ cm})^2(5.5\text{ nC})^2 - 4(5.5\text{ nC} - 11\text{ nC})(88\text{ cm})^2(5.5\text{ nC})}}{2(5.5\text{ nC} - 11\text{ nC})}$ $x = \boxed{36\text{ cm}}$

398. $q_1 = 72$ C $q_3 = -8.0$ C $r_{1,2} = 15\text{ mm} = 1.5 \times 10^{-2}$ m $r_{3,1} = -9.0\text{ mm} = -9.0 \times 10^{-3}$ m $r_{3,2} = 2.4 \times 10^{-2}$ m	$F_{3,1} + F_{3,2} = \frac{-k_C q_3 q_1}{r_{3,1}^2} - \frac{k_C q_3 q_2}{r_{3,2}^2} = 0$ $q_2 = \frac{-q_1 r_{3,2}^2}{r_{3,1}^2} = \frac{-(72\text{ C})(2.4 \times 10^{-2}\text{ m})^2}{(-9.0 \times 10^{-3}\text{ m})^2} = \boxed{-512\text{ C}}$

Electrical Energy and Current

399. $q = 1.45 \times 10^{-8}$ C $E = 105$ N/C $d = 290$ m	$PE_{electric} = -qEd = -(1.45 \times 10^{-8}\text{ C})(-105\text{ N/C})(290\text{ m})$ $PE_{electric} = \boxed{4.4 \times 10^{-4}\text{ J}}$
400. $PE_{electric} = -1.39 \times 10^{11}$ J $E = 3.4 \times 10^5$ N/C $d = 7300$ m	$q = \frac{-PE_{electric}}{Ed} = \frac{-(-1.39 \times 10^{11}\text{ J})}{(3.4 \times 10^5\text{ N/C})(7300\text{ m})}$ $q = \boxed{56\text{ C}}$
401. $R = 6.4 \times 10^6$ m	$C_{sphere} = \frac{R}{k_c} = \frac{6.4 \times 10^6\text{ m}}{8.99 \times 10^9\text{N•m}^2/\text{C}^2} = \boxed{7.1 \times 10^{-4}\text{ F}}$
402. $C = 5.0 \times 10^{-13}$ F $\Delta V = 1.5$ V	$Q = C\Delta V = (5 \times 10^{-13}\text{ F})(1.5\text{ V}) = \boxed{7.5 \times 10^{-13}\text{ C}}$
403. $\Delta Q = 76$ C $\Delta t = 19$ s	$I = \frac{\Delta Q}{\Delta t} = \frac{76\text{ C}}{19\text{ s}} = \boxed{4.0\text{ A}}$
404. $\Delta Q = 98$ C $I = 1.4$ A	$\Delta t = \frac{\Delta Q}{I} = \frac{98\text{ C}}{1.4\text{ A}} = \boxed{70\text{ s}}$
405. $I = 0.75$ A $\Delta V = 120$ V	$R = \frac{\Delta V}{I} = \frac{120\text{ V}}{0.75\text{A}} = \boxed{1.6 \times 10^2\ \Omega}$
406. $\Delta V = 120$ V $R = 12.2\ \Omega$	$I = \frac{\Delta V}{R} = \frac{120\text{ V}}{12.2\ \Omega} = \boxed{9.84\text{ A}}$

Givens	Solutions
407. $\Delta V = 720$ V $R = 0.30\ \Omega$	$P = \frac{(\Delta V)^2}{R} = \frac{(720\ V)^2}{0.30\ \Omega} = \boxed{1.7 \times 10^6\ W}$
408. $\Delta V = 120$ V $P = 1750$ W	$R = \frac{(\Delta V)^2}{P} = \frac{(120\ V)^2}{1750\ W} = \boxed{8.23\ \Omega}$
409. $q = 64\ nC = 64 \times 10^9$ C $d = 0.95$ m $\Delta PE_{electric} = -3.88 \times 10^{-5}$ J	$E = -\frac{\Delta PE_{electric}}{qd} = -\frac{-3.88 \times 10^{-5}\ 5\ J}{(64 \times 10^9\ C)(0.95)}$ $E = \boxed{6.4 \times 10^2\ N/C}$
410. $q = -14\ nC = -14 \times 10^{-9}$ C $E = 156$ N/C $\Delta PE_{electric} = 2.1 \times 10^{-6}$ J	$d = \frac{\Delta PE_{electric}}{-qE} = \frac{2.1 \times 10^{-6}\ J}{-(-14 \times 10^{-9}\ C)(156\ N/C)}$ $d = \boxed{0.96\ m = 96\ cm}$
411. $C = 5.0 \times 10^{-5}$ F $Q = 6.0 \times 10^{-4}$ C	$\Delta V = \frac{Q}{C} = \frac{6.0 \times 10^{-4}\ C}{5.0 \times 10^{-5}\ F} = \boxed{12\ V}$
412. $Q = 3 \times 10^{-2}$ C $\Delta V = 30$ kV	$C = \frac{Q}{\Delta V} = \frac{3 \times 10^{-2}\ C}{30 \times 10^3\ V} = \boxed{1 \times 10^{-6}\ F = 1\ \mu F}$
413. $A = 6.4 \times 10^{-3}\ m^2$ $C = 4.55 \times 10^{-9}$ F	$d = \frac{\varepsilon_0 A}{C} = \frac{(8.85 \times 10^{-12}\ C^2/N{\bullet}m^2)(6.4 \times 10^{-3}\ m^2)}{4.55 \times 10^{-9}\ F}$ $d = \boxed{1.2 \times 10^{-5}\ m}$
414. $C = 1.4 \times 10^{-5}$ F $\Delta V = 1.5 \times 10^4$ V	$Q = C\Delta V = (1.4 \times 10^{-5}\ F)(1.5 \times 10^4\ V) = \boxed{0.21\ C}$
415. $\Delta t = 15$ s $I = 9.3$ A	$\Delta Q = I\Delta t = (9.3\ A)(15\ s) = \boxed{1.4 \times 10^2\ C}$
416. $\Delta Q = 1.14 \times 10^{-4}$ C $\Delta t = 0.36$ s	$I = \frac{\Delta Q}{\Delta t} = \frac{1.14 \times 10^{-4}\ C}{0.36\ s} = \boxed{0.32\ mA}$
417. $\Delta Q = 56$ C $I = 7.8$ A	$\Delta t = \frac{\Delta Q}{I} = \frac{56\ C}{7.8\ A} = \boxed{7.2\ s}$
418. $\Delta t = 2.0\ min = 120$ s $I = 3.0$ A	$\Delta Q = I\Delta t = (3.0\ A)(120\ s) = \boxed{3.6 \times 10^2\ C}$
419. $I = 0.75$ A $R = 6.4\ \Omega$	$\Delta V = IR = (0.75\ A)(6.4\ \Omega) = \boxed{4.8\ V}$

Givens	*Solutions*
420. $\Delta V = 650\ V$ $R = 1.0 \times 10^2\ \Omega$	$I = \frac{\Delta V}{R} = \frac{650\ V}{1.0 \times 10^2\ \Omega} = \boxed{6.5\ A}$
421. $I = 4.66\ A$ $R = 25.0\ \Omega$	$\Delta V = IR = (4.66\ A)\ (25.0\ \Omega) = \boxed{116\ V}$
422. $I = 0.545\ A$ $\Delta V = 120\ V$	$R = \frac{\Delta V}{I} = \frac{120\ V}{0.545\ A} = \boxed{220\ \Omega}$
423. $\Delta V = 2.5 \times 10^4\ V$ $I = 20.0\ A$	$P = I\Delta V = (20.0\ A)\ (2.5 \times 10^4\ V) = \boxed{5.0 \times 10^5\ W}$
424. $P = 230\ W$ $R = 91\ \Omega$	$I^2 = \frac{P}{R}$ $\quad I = \sqrt{\frac{P}{R}} = \sqrt{\frac{230\ W}{91\ \Omega}} = \boxed{1.59\ A}$
425. $I = 8.0 \times 10^6\ A$ $P = 6.0 \times 10^{13}\ W$	$\Delta V = \frac{P}{I} = \frac{6.0 \times 10^{13}\ W}{8.0 \times 10^6\ A} = \boxed{7.5 \times 10^6\ V}$
426. $P = 350\ W$ $R = 75\ \Omega$	$I^2 = \frac{P}{R}$ $\quad I = \sqrt{\frac{P}{R}} = \sqrt{\frac{350\ W}{75\ \Omega}} = \boxed{2.2\ A}$

Circuits and Circuit Elements

427. 25 speakers $R_{each\ speaker} = 12.0\ \Omega$	$R_{eq} = \Sigma R_{each\ speaker}$ All speakers have equal resistance. $R_{eq} = (25)(12.0\ \Omega) = \boxed{3.00 \times 10^2\ \Omega}$
428. 57 lights $R_{each\ light} = 2.0\ \Omega$	$R_{eq} = \Sigma R_{each\ light}$ All lights have equal resistance. $R_{eq} = (57)(2.0\ \Omega) = \boxed{114\ \Omega}$
429. $R_1 = 39\ \Omega$ $R_2 = 82\ \Omega$ $R_3 = 12\ \Omega$ $R_4 = 22\ \Omega$ $\Delta V = 3.0\ V$	$\frac{1}{R_{eq}} = \frac{1}{R_1} + \frac{1}{R_2} + \frac{1}{R_3} + \frac{1}{R_4} = \frac{1}{39\ \Omega} + \frac{1}{82\ \Omega} + \frac{1}{12\ \Omega} + \frac{1}{22\ \Omega}$ $\frac{1}{R_{eq}} = \frac{0.026}{1\ \Omega} + \frac{0.012}{1\ \Omega} + \frac{0.083}{1\ \Omega} + \frac{0.045}{1\ \Omega} = \frac{0.17}{1\ \Omega}$ $R_{eq} = \boxed{6.0\ \Omega}$
430. $R_1 = 33\ \Omega$ $R_2 = 39\ \Omega$ $R_3 = 47\ \Omega$ $R_4 = 68\ \Omega$ $V = 1.5\ V$	$\frac{1}{R_{eq}} = \frac{1}{R_1} + \frac{1}{R_2} + \frac{1}{R_3} + \frac{1}{R_4} = \frac{1}{33\ \Omega} + \frac{1}{39\ \Omega} + \frac{1}{47\ \Omega} + \frac{1}{68\ \Omega}$ $\frac{1}{R_{eq}} = \frac{0.030}{1\ \Omega} + \frac{0.026}{1\ \Omega} + \frac{0.021}{1\ \Omega} + \frac{0.015}{1\ \Omega}$ $R_{eq} = \boxed{11\ \Omega}$

Givens	Solutions
431. $\Delta V = 12$ V $R_1 = 16\ \Omega$ $I = 0.42$ A	$R_2 = \frac{\Delta V}{I} - R_1 = \frac{12\text{ V}}{0.42\text{ A}} - 16\ \Omega = 29\ \Omega - 16\ \Omega = \boxed{13\ \Omega}$
432. $\Delta V = 3.0$ V $R_1 = 24\Omega$ $I = 0.062$ A	$R_2 = \frac{\Delta V}{I} - R_1 = \frac{3.0\text{ V}}{0.062\text{ A}} - 24\ \Omega = 48\ \Omega - 24\ \Omega = \boxed{24\ \Omega}$
433. $\Delta V = 3.0$ V $R_1 = 3.3\ \Omega$ $I = 1.41$ A	$\Delta V = IR_{eq}$ $I = \frac{\Delta V}{R_{eq}} = \frac{\Delta V}{R_1} + \frac{\Delta V}{R_2}$ $\frac{\Delta V}{R_2} = \left(I - \frac{\Delta V}{R_1}\right)$ $R_2 = \frac{\Delta V}{\left(I - \frac{\Delta V}{R_1}\right)} = \frac{3.0\text{ V}}{\left(1.41\text{ A} - \frac{3.0\text{ V}}{3.3\ \Omega}\right)} = \frac{3.0\text{ V}}{[1.41\text{ A} - 0.91\text{ A}]} = \boxed{6.0\ \Omega}$
434. $\Delta V = 12$ V $R_1 = 56\ \Omega$ $I = 3.21$ A	$\Delta V = IR_{eq}$ $I = \frac{\Delta V}{R_{eq}} = \frac{\Delta V}{R_1} + \frac{\Delta V}{R_2}$ $\frac{\Delta V}{R_2} = \left(I - \frac{\Delta V}{R_1}\right)$ $R_2 = \frac{\Delta V}{\left(I - \frac{\Delta V}{R_1}\right)} = \frac{12\text{ V}}{\left(3.21\text{ A} - \frac{12\text{ V}}{56\ \Omega}\right)} = \frac{12\text{ V}}{[3.21\text{ A} - 0.21\text{ A}]} = \boxed{4.0\ \Omega}$
435. $R_1 = 56\ \Omega$ $R_2 = 82\ \Omega$ $R_3 = 24\ \Omega$ $\Delta V = 9.0$ V	$R_{eq} = \Sigma R = R_1 + R_2 + R_3 = 56\Omega + 82\Omega + 24\Omega = 162\Omega$ $I = \frac{\Delta V}{R_{eq}} = \frac{9.0\ V}{162\ \Omega} = \boxed{56\text{ mA}}$
436. $R_1 = 96\ \Omega$ $R_2 = 48\ \Omega$ $R_3 = 29\ \Omega$ $\Delta V = 115$ V	$R_{eq} = \Sigma R = R_1 + R_2 + R_3 = 96\ \Omega + 48\ \Omega + 29\ \Omega = 173\ \Omega$ $I = \frac{\Delta V}{R_{eq}} = \frac{115\text{ V}}{173\ \Omega} = \boxed{665\text{ mA}}$
437. $\Delta V = 120$ V $R_1 = 75\ \Omega$ $R_2 = 91\ \Omega$	$I_1 = \frac{V}{R_1}$ $I_2 = \frac{V}{R_2}$ $I_1 = \frac{120\text{ V}}{75\ \Omega} = \boxed{1.6\text{ A}}$ $I_2 = \frac{120\text{ V}}{91\ \Omega} = \boxed{1.3\text{ A}}$

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438. $\Delta V = 120$ V, $R_1 = 82\ \Omega$, $R_2 = 24\ \Omega$

$$I_1 = \frac{V}{R_1} \qquad I_2 = \frac{V}{R_2}$$

$$I_1 = \frac{120\ \text{V}}{82\ \Omega} = \boxed{1.5\ \text{A}} \qquad I_2 = \frac{120\ \text{V}}{24\ \Omega} = \boxed{5.0\ \text{A}}$$

I

439. $R_1 = 1.5\ \Omega$, $R_2 = 6.0\ \Omega$, $R_3 = 5.0\ \Omega$, $R_4 = 4.0\ \Omega$, $R_5 = 2.0\ \Omega$, $R_6 = 5.0\ \Omega$, $R_7 = 3.0\ \Omega$

Parallel:

Group (a): $$\frac{1}{R_{eq.a}} = \frac{1}{R_2} + \frac{1}{R_3} = \frac{1}{6.0\ \Omega} + \frac{1}{5.0\ \Omega} = \frac{5.0 + 6.0}{30\ \Omega}$$

$$R_{eq,a} = \frac{30\ \Omega}{11.0} = 2.7\ \Omega$$

Group (b): $$\frac{1}{R_{eq.a}} = \frac{1}{R_5} + \frac{1}{R_6} = \frac{1}{2.0\ \Omega} + \frac{1}{5.0\ \Omega} = \frac{5.0 + 2.0}{10\ \Omega}$$

$$R_{eq,a} = \frac{10\ \Omega}{7.0} = 1.4\ \Omega$$

Series:

$$R_{eq} = R_1 + R_{eq,a} + R_4 + R_{eq,b} + R_7 = 1.5\ \Omega + 2.7\ \Omega + 4.0\ \Omega + 1.4\ \Omega + 3.0\ \Omega$$

$$R_{eq} = \boxed{12.6\ \Omega}$$

440. $\Delta V_{tot} = 12.0$ V, $R_{eq} = 12.6\ \Omega$

$$I_{tot} = \frac{\Delta V_{tot}}{R_{eq}} = \frac{12.0\ \text{V}}{12.6\ \Omega} = \boxed{0.952\ \text{A}}$$

441. $I_{tot} = 0.952$ A, $R_2 = 6.0\ \Omega$, $R_3 = 5.0\ \Omega$

$$\frac{1}{R_{eq.a}} = \frac{1}{R_2} + \frac{1}{R_3} = \frac{1}{6.0\ \Omega} + \frac{1}{5.0\ \Omega} = \frac{5.0 + 6.0}{30\ \Omega}$$

$$R_{eq,a} = 2.7\ \Omega$$

$$\Delta V_2 = \Delta V_a = I_{tot}R_{eq,a} = (0.952\ \text{A})(2.7\ \Omega) = \boxed{2.6\ \text{V}}$$

442. $\Delta V_2 = 2.6$ V, $R_2 = 6.0\ \Omega$

$$I_6 = \frac{\Delta V_2}{R_2} = \frac{2.6\ \text{V}}{6.0\ \Omega} = \boxed{0.43\ \text{A}}$$

443. $R_1 = 3.0\ \Omega$, $R_2 = 5.0\ \Omega$, $R_3 = 5.0\ \Omega$, $R_4 = 5.0\ \Omega$, $R_5 = 5.0\ \Omega$, $R_6 = 5.0\ \Omega$, $R_7 = 5.0\ \Omega$, $R_8 = 3.0\ \Omega$

Parallel:

$$\frac{1}{R_{eq.a}} = \frac{1}{R_2} + \frac{1}{R_3} + \frac{1}{R_4} = \frac{1}{5.0\ \Omega} + \frac{1}{5.0\ \Omega} + \frac{1}{5.0\ \Omega} = 3(0.20\ \Omega)$$

$$R_{eq,a} = 1.7\ \Omega = R_{eq,b}$$

Series:

$$R_{eq} = R_1 + R_{eq,a} + R_8 + R_{eq,b} = 3.0\ \Omega + 1.7\ \Omega + 3.0\ \Omega + 1.7\ \Omega$$

$$R_{eq} = \boxed{9.4\ \Omega}$$

Givens	*Solutions*

444. $\Delta V_{tot} = 15.0\ \text{V}$

$R_{eq} = 9.4\ \Omega$

$$I_{tot} = \frac{\Delta V_{tot}}{R_{eq}} = \frac{15.0\ \text{V}}{9.4\ \Omega} = \boxed{1.6\ \text{A}}$$

445. $I_{tot} = 1.6\ \text{A}$

$$I_1 = I_{tot} = \boxed{1.6\ \text{A}}$$

446. $R_1 = 3.0\ \Omega$

$R_2 = 2.0\ \Omega$

$R_3 = 3.0\ \Omega$

$R_4 = 4.0\ \Omega$

$R_5 = 8.0\ \Omega$

$R_6 = 5.0\ \Omega$

$R_7 = 2.0\ \Omega$

$R_8 = 8.0\ \Omega$

$R_9 = 4.0\ \Omega$

Parallel:

$$\frac{1}{R_{eq.a}} = \frac{1}{R_1} + \frac{1}{R_2} = \frac{1}{3.0\ \Omega} + \frac{1}{2.0\ \Omega} = \frac{2.0 + 3.0}{6.0\ \Omega}$$

$$R_{eq,a} = \frac{6.0\ \Omega}{5.0} = 1.2\ \Omega$$

$$\frac{1}{R_{eq.b}} = \frac{1}{R_4} + \frac{1}{R_5} = \frac{1}{4.0\ \Omega} + \frac{1}{8.0\ \Omega} = \frac{8.0 + 4.0}{32\ \Omega}$$

$$R_{eq,b} = \frac{32\ \Omega}{12.0} = 2.7\ \Omega = R_{eq,c}$$

Series:

$$R_{eq} = R_{eq,a} + R_3 + R_{eq,b} + R_6 + R_7 + R_{eq,c}$$

$$R_{eq} = 1.2\ \Omega + 3.0\ \Omega + 2.7\ \Omega + 5.0\ \Omega + 2.0\ \Omega + 2.7\ \Omega = \boxed{16.6\ \Omega}$$

447. $\Delta V_{tot} = 24.0\ \text{V}$

$R_{eq} = 16.6\ \Omega$

$$I_{tot} = \frac{\Delta V_{tot}}{R_{eq}} = \frac{24.0\ \text{V}}{16.6\ \Omega} = \boxed{1.45\ \text{A}}$$

448. $I_{tot} = 1.45\ \text{A}$

$R_4 = R_9 = 4.0\ \Omega$

$R_5 = R_8 = 8.0\ \Omega$

$$I_{tot} = I_4 + I_5$$

$$I_5 = I_{tot} - I_4$$

$$\Delta V_4 = \Delta V_5$$

$$I_4 R_4 = I_5 R_5$$

$$I_4 R_4 = (I_{tot} - I_4) R_5$$

$$I_4 (R_4 + R_5) = I_{tot} R_5$$

$$I_4 = I_{tot}\left(\frac{R_5}{R_4 + R_5}\right) = (1.45\ \text{A})\left(\frac{8.0\ \Omega}{4.0\ \Omega + 8.0\ \Omega}\right) = (1.45\ \text{A})\left(\frac{8.0}{12.0}\right) = \boxed{0.97\ \text{A}}$$

Magnetism

449. $q = 1.60 \times 10^{-19}\ \text{C}$

$B = 0.8\ \text{T}$

$v = 3.0 \times 10^{7}\ \text{m/s}$

$$F_{magnetic} = qvB = (1.60 \times 10^{-19}\ \text{C})(3.0 \times 10^{7}\ \text{m/s})(0.8\ \text{T}) = \boxed{4 \times 10^{-12}\ \text{N}}$$

450. $q = 1.60 \times 10^{-19}\ \text{C}$

$v = 3.9 \times 10^{6}\ \text{m/s}$

$F_{magnetic} = 1.9 \times 10^{-22}\ \text{N}$

$$B = \frac{F_{magnetic}}{qv} = \frac{1.9 \times 10^{-22}\ \text{N}}{(1.60 \times 10^{-19}\ \text{C})(3.9 \times 10^{6}\ \text{m/s})} = \boxed{3.0 \times 10^{-10}\ \text{T}}$$

451. $q = 1.60 \times 10^{-19}\ \text{C}$

$B = 5.0 \times 10^{-5}\ \text{T}$

$F_{magnetic} = 6.1 \times 10^{-17}\ \text{N}$

$$v = \frac{F_{magnetic}}{qB} = \frac{6.1 \times 10^{-17}\ \text{N}}{(1.60 \times 10^{-19}\ \text{C})(5.0 \times 10^{-5}\ \text{T})} = \boxed{7.6 \times 10^{6}\ \text{m/s}}$$

Givens	*Solutions*
452. $I = 14$ A $\ell = 2$ m $B = 3.6 \times 10^{-4}$ T	$F_{magnetic} = BI\ell = (3.6 \times 10^{-4}\ \text{T})(14\ \text{A})(2\ \text{m}) = \boxed{1 \times 10^{-2}\ \text{N}}$
453. $\ell = 1.0$ m $F_{magnetic} = 9.1 \times 10^{-5}$ N $B = 1.3 \times 10^{-4}$ T	$I = \frac{F_{magnetic}}{B\ell} = \frac{9.1 \times 10^{-5}\ \text{N}}{(1.3 \times 10^{-4}\ \text{T})(1.0\ \text{m})} = \boxed{0.70\ \text{A}}$
454. $B = 4.6 \times 10^{-4}$ T $F_{magnetic} = 2.9 \times 10^{-3}$ N $T = 10.0$ A	$\ell = \frac{F_{magnetic}}{BI} = \frac{2.9 \times 10^{-3}\ \text{N}}{(4.6 \times 10^{-4}\ \text{T})(10.0\ \text{A})} = \boxed{0.63\ \text{m}}$
455. $\ell = 12$ m $I = 12$ A $F_{magnetic} = 7.3 \times 10^{-2}$ N	$B = \frac{F_{magnetic}}{I\ell} = \frac{7.3 \times 10^{-2}\ \text{N}}{(12\ \text{A})(12\ \text{m})} = \boxed{5.1 \times 10^{-4}\ \text{T}}$
456. $q = 1.60 \times 10^{-19}$ C $v = 7.8 \times 10^{6}$ m/s $F_{magnetic} = 3.7 \times 10^{-13}$ N	$B = \frac{F_{magnetic}}{qv} = \frac{3.7 \times 10^{-13}\ \text{N}}{(1.60 \times 10^{-19}\ \text{C})(7.8 \times 10^{6}\ \text{m/s})} = \boxed{0.30\ \text{T}}$
457. $q = 1.60 \times 10^{-19}$ C $v = 2.2 \times 10^{6}$ m/s $B = 1.1 \times 10^{-2}$ T	$F_{magnetic} = qvB = (1.60 \times 10^{-19}\ \text{C})(2.2 \times 10^{6}\ \text{m/s})(1.1 \times 10^{-2}\ \text{T}) = \boxed{3.9 \times 10^{-15}\ \text{N}}$
458. $B = 1 \times 10^{-8}$ T $q = 1.60 \times 10^{-19}$ C $F_{magnetic} = 3.2 \times 10^{-22}$ N	$v = \frac{F_{magnetic}}{qB} = \frac{3.2 \times 10^{-22}\ \text{N}}{(1.60 \times 10^{-19}\ \text{C})(1 \times 10^{-8}\ \text{T})} = \boxed{2 \times 10^{5}\ \text{m/s}}$
459. $\ell = 10$ m $m = 75$ kg $B = 4.8 \times 10^{-4}$ T $g = 9.81$ m/s^2	$mg = BI\ell$ $I = \frac{mg}{B\ell} = \frac{(75\ \text{kg})(9.81\ \text{m/s}^2)}{(4.8 \times 10^{-4}\ \text{T})(10\ \text{m})} = \boxed{1.5 \times 10^{5}\ \text{A}}$
460. $I = 1.5 \times 10^{3}$ A $\ell = 15$ km $= 1.4 \times 10^{4}$ m $\theta = 45°$ $B = 2.3 \times 10^{-5}$ T	$F_{magnetic} = B\cos\theta I\ell = (2.3 \times 10^{-5}\ \text{T})\cos 45°(1.5 \times 10^{3}\ \text{A})(1.5 \times 10^{4}\ \text{m})$ $F_{magnetic} = \boxed{3.7 \times 10^{2}\ \text{N}}$

Electromagnetic Induction

461. $N = 540$ turns $A = 0.016$ m^2 $\theta_i = 0°$ $\theta_f = 90.0°$ $\Delta t = 0.05$ s emf = 3.0 V	$B = \frac{\text{emf}\,\Delta t}{-NA\Delta\cos\theta} = \frac{\text{emf}\,\Delta t}{-NA[\cos\theta_f - \cos\theta_i]}$ $B = \frac{(3.0\ \text{V})(0.05\ \text{s})}{-(540)(0.016\ \text{m}^2)[\cos 90.0° - \cos 0°]}$ $B = \boxed{1.7 \times 10^{-2}\ \text{T}}$

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Givens	Solutions
462. $N = 550$ turns $A = 5.0 \times 10^{-5}\ m^2$ $\Delta B = 2.5 \times 10^{-4}$ T $\Delta t = 2.1 \times 10^{-5}$ s $\theta = 0°$	$\text{emf} = \frac{-NA\Delta B \cos\theta}{\Delta t}$ $\text{emf} = \frac{-(550)(5.0\times10^{-5}\ m^2)(2.5\times10^{-4}\ T)(\cos 0°)}{2.1\times10^{-5}\ s}$ $\text{emf} = \boxed{0.33\ V}$
463. $N = 246$ turns $A = 0.40\ m^2$ $\theta = 0°$ $B_i = 0.237$ T $B_f = 0.320$ T $\Delta t = 0.9$ s emf = 9.1 V	$\Delta t = \frac{-NA\Delta B\cos\theta}{\text{emf}} = \frac{-NA[B_f - B_i]\cos\theta}{\text{emf}}$ $\Delta t = \frac{-(246)(0.40\ m^2)[0.320\ T - 0.237\ T](\cos 0°)}{9.1\ V}$ $\Delta t = \boxed{0.90\ s}$
464. $emf = 9.5$ V $\theta_i = 0.0°$ $\theta_f = 90.0°$ $B = 1.25 \times 10^{-2}$ T $\Delta t = 25$ ms $A = 250\ cm^2$	$N = \frac{emf\,\Delta t}{-A\Delta(B\cos\theta)} = \frac{emf\,\Delta t}{-AB(\cos\theta_f - \cos\theta_i)}$ $N = \frac{(9.5\ V)(25\times10^{-3}\ s)}{-(250\ cm^2)(1.25\times10^{-2}\ T)(\cos 90.0° - \cos 0.0°)}$ $N = \boxed{7.6\times10^2\ \text{turns}}$
465. $\Delta V_{rms} = 320$ V $R = 100\ \Omega$	$\Delta V_{max} = \frac{\Delta V_{rms}}{0.707} = \frac{320\ V}{0.707} = \boxed{450\ V}$
466. $\Delta V_{rms} = 320$ V $R = 100\ \Omega$	$I_{rms} = \frac{\Delta V_{rms}}{R} = \frac{320\ V}{100\ \Omega} = \boxed{3\ A}$
467. $I_{rms} = 1.3$ A	$I_{max} = \frac{I_{rms}}{0.707} = \frac{1.3\ A}{0.707} = \boxed{1.8\ A}$
468. $\Delta V_2 = 6.9 \times 10^3$ V $N_1 = 1400$ turns $N_2 = 140$ turns	$\Delta V_1 = \Delta V_2 \frac{N_1}{N_2} = (6.9\times10^3\ V)\left(\frac{1400}{140}\right) = \boxed{6.9\times10^4\ V}$
469. $\Delta V_1 = 5600$ V $N_1 = 140$ turns $N_2 = 840$ turns	$\Delta V_2 = \Delta V_1 \frac{N_2}{N_1} = (5600\ V)\left(\frac{840}{140}\right) = \boxed{3.4\times10^4\ V}$
470. $\Delta V_1 = 1800$ V $\Delta V_2 = 3600$ V $N_1 = 58$ turns	$N_2 = N_1 \frac{\Delta V_2}{\Delta V_1} = (58\ \text{turns})\left(\frac{1800\ V}{3600\ V}\right) = \boxed{29\ \text{turns}}$
471. $\Delta V_1 = 4900$ V $\Delta V_2 = 4.9 \times 10^4$ V $N_2 = 480$ turns	$N_1 = N_2 \frac{\Delta V_1}{\Delta V_2} = (480)\left(\frac{4900\ V}{4.9\times10^4\ V}\right) = \boxed{48\ \text{turns}}$

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Givens	*Solutions*
472. $N = 320$ turns $\theta_i = 0.0°$ $\theta_f = 90.0°$ $B = 0.046$ T $\Delta t = 0.25$ s emf = 4.0 V	$A = \frac{\text{emf}\,\Delta t}{-N\Delta(B\cos\theta)} = \frac{\text{emf}\,\Delta t}{-NB(\cos\theta_f - \cos\theta_i)}$ $A = \frac{(4.0\text{ V})(0.25\text{ s})}{-(320)(0.046\text{ T})(\cos 90.0° - \cos 0.0°)}$ $A = \boxed{6.8 \times 10^{-2}\text{ m}^2}$
473. $N = 180$ turns $A = 5.0 \times 10^{-5}\text{ m}^2$ $\Delta B = 5.2 \times 10^{-4}$ T $\theta = 0°$ $\Delta t = 1.9 \times 10^{-5}$ s $R = 1.0 \times 10^2\,\Omega$	$\text{emf} = \frac{-NA\Delta B\cos\theta}{\Delta t}$ $\text{emf} = \frac{-(180)(5.0 \times 10^{-5}\text{ m}^2)(5.2 \times 10^{-4}\text{ T})(\cos 0°)}{1.9 \times 10^{-5}\text{ s}}$ emf = 0.25 V $I = \frac{\text{emf}}{R} = \frac{0.25\text{ V}}{1.0 \times 10^2\,\Omega} = \boxed{2.5 \times 10^{-3}\text{ A} = 25\text{ mA}}$
474. $I_{max} = 1.2$ A $\Delta V_{max} = 211$ V	$\Delta V_{rms} = 0.707\ V_{max} = 0.707(211\text{ V}) = \boxed{149\text{ V}}$
475. $I_{max} = 1.2$ A $\Delta V_{max} = 211$ V	$I_{rms} = 0.707\ I_{max} = 0.707(1.2\text{ A}) = \boxed{0.85\text{ A}}$
476. $V_{max} = 170$ V	$\Delta V_{rms} = 0.707\ V_{max} = 0.707(170\text{ V}) = \boxed{120\text{ V}}$
477. $\Delta V_1 = 240$ V $\Delta V_2 = 5.0$ V	$\frac{N_1}{N_2} = \frac{\Delta V_1}{\Delta V_2} = \frac{240\text{ V}}{5.0\text{ V}} = \boxed{48{:}1}$

Atomic Physics

478. $\lambda = 527\text{ nm} = 5.27 \times 10^{-7}$ m	$E = hf = \frac{hc}{\lambda} = \frac{(6.63 \times 10^{-34}\text{ J•s})(3.00 \times 10^8\text{ m/s})}{5.27 \times 10^{-7}\text{ m}} = \boxed{3.77 \times 10^{-19}\text{ J}}$
479. $m_e = 9.109 \times 10^{-31}$ kg $v = 2.19 \times 10^6$ m/s	$\lambda = \frac{h}{mv} = \frac{6.63 \times 10^{-34}\text{ J•s}}{(9.109 \times 10^{-31}\text{ kg})(2.19 \times 10^6\text{ m/s})} = \boxed{3.32 \times 10^{-10}\text{ m}}$
480. $E = 20.7$ eV	$f = \frac{E}{h} = \frac{(20.7\text{ eV})(1.60 \times 10^{-19}\text{ J/eV})}{6.63 \times 10^{-34}\text{ J•s}} = \boxed{5.00 \times 10^{15}\text{ Hz}}$
481. $E = 12.4$ MeV $= 1.24 \times 10^7$ eV	$\lambda = \frac{hc}{E} = \frac{(6.63 \times 10^{-34}\text{ J•s})(3.00 \times 10^8\text{ m/s})}{(1.24 \times 10^7\text{ eV})(1.60 \times 10^{-19}\text{ J/eV})} = \boxed{1.00 \times 10^{-13}\text{ m}}$
482. $\lambda = 240\text{ nm} = 2.4 \times 10^{-7}$ m $hf_t = 2.3$ eV	$KE_{max} = \frac{hc}{\lambda} - hf_t$ $KE_{max} = \frac{(6.63 \times 10^{-34}\text{ J•s})(3.00 \times 10^8\text{ m/s})}{2.4 \times 10^{-7}\text{ m})(1.60 \times 10^{-19}\text{ J/eV})} - 2.3\text{ eV}$ $KE_{max} = 5.2\text{ eV} - 2.3\text{ eV} = \boxed{2.9\text{ eV}}$

Givens	Solutions
483. $hf_t = 4.1$ eV	$\lambda = \frac{hc}{E} = \frac{(6.63 \times 10^{-34}\ \text{J•s})(3.00 \times 10^8\ \text{m/s})}{(4.1\ \text{eV})(1.60 \times 10^{-19}\ \text{eV})} = \boxed{3.0 \times 10^{-7}\ \text{m} = 300\ \text{nm}}$
484. $\lambda = 2.64 \times 10^{-14}$ m $m_p = 1.67 \times 10^{-27}$ kg	$v = \frac{\text{h}}{m\lambda} = \frac{6.63 \times 10^{-34}\ \text{J•s}}{(1.67 \times 10^{-27}\ \text{kg})(2.64 \times 10^{-14}\ \text{m})} = \boxed{1.50 \times 10^7\ \text{m/s}}$
485. $v = 28$ m/s $\lambda = 8.97 \times 10^{-37}$ m	$m = \frac{h}{\lambda v} = \frac{6.63 \times 10^{-34}\ \text{J•s}}{(8.97 \times 10^{-37}\ \text{m})(28\ \text{m/s})} = \boxed{26\ \text{kg}}$
486. $\lambda = 430.8$ nm $= 4.308 \times 10^{-7}$ m	$E = hf = \frac{hc}{\lambda} = \frac{(6.63 \times 10^{-34}\ \text{J•s})(3.00 \times 10^8\ \text{m/s})}{4.308 \times 10^{-7}\ \text{m}} = \boxed{4.62 \times 10^{-19}\ \text{J}}$
487. $E = 1.78$ eV	$f = \frac{E}{h} = \frac{(1.78\ \text{eV})(1.60 \times 10^{-19}\ \text{J/eV})}{6.63 \times 10^{-34}\ \text{J•s}} = \boxed{4.30 \times 10^{14}\ \text{Hz}}$
488. $E = 3.1 \times 10^{-6}$ eV	$\lambda = \frac{hc}{E} = \frac{(6.63 \times 10^{-34}\ \text{J•s})(3.00 \times 10^8\ \text{m/s})}{(3.1 \times 10^{-6}\ \text{eV})(1.60 \times 10^{-19}\ \text{J/eV})} = \boxed{0.40\ \text{m}}$
489. $f = 6.5 \times 10^{14}$ Hz $KE_{max} = 0.20$ eV	$f_t = \frac{hf - KE_{max}}{h}$ $f_t = \frac{[(6.63 \times 10^{-34}\ \text{J•s})(6.5 \times 10^{14}\ \text{Hz}) - (0.20\ \text{eV})(1.60 \times 10^{-19}\ \text{J/eV})]}{6.63 \times 10^{-34}\ \text{J•s}}$ $f_t = \boxed{6.0 \times 10^{14}\ \text{Hz}}$
490. $\lambda = 519\ \text{nm} = 5.19 \times 10^{-7}$ m $hf_t = 2.16$ eV	$KE_{max} = \frac{hc}{\lambda} - hf_t$ $KE_{max} = \frac{(6.63 \times 10^{-34}\ \text{J•s})(3.00 \times 10^8\ \text{m/s})}{(5.19 \times 10^{-7}\ \text{m})(1.60 \times 10^{-19}\ \text{J/eV})} - 2.16\ \text{eV}$ $KE_{max} = 2.40\ \text{eV} - 2.16\ \text{eV} = \boxed{0.24\ \text{eV}}$
491. $v = 5.6 \times 10^{-6}$ m/s $\lambda = 2.96 \times 10^{-8}$ m	$m = \frac{h}{\lambda v} = \frac{6.63 \times 10^{-34}\ \text{J•s}}{(2.96 \times 10^{-8}\ \text{m})(5.6 \times 10^{-6}\ \text{m/s})} = \boxed{4.0 \times 10^{-21}\ \text{kg}}$
492. $f_t = 1.36 \times 10^{15}$ Hz	$hf_t = \frac{(6.63 \times 10^{-34}\ \text{J•s})(1.36 \times 10^{15}\ \text{Hz})}{1.60 \times 10^{-19}\ \text{J/eV}} = \boxed{5.64\ \text{eV}}$
493. $m = 7.6 \times 10^7$ kg $v = 35$ m/s	$\lambda = \frac{h}{mv} = \frac{6.63 \times 10^{-34}\ \text{J•s}}{(7.6 \times 10^7\ \text{kg})(35\ \text{m/s})} = \boxed{2.5 \times 10^{-43}\ \text{m}}$
494. $hf_t = 5.0$ eV	$\lambda = \frac{hc}{E} = \frac{(6.63 \times 10^{-34}\ \text{J•s})(3.00 \times 10^8\ \text{m/s})}{(5.0\ \text{eV})(1.60 \times 10^{-19}\ \text{eV})} = \boxed{2.5 \times 10^{-7}\ \text{m} = 250\ \text{nm}}$

Givens	Solutions
495. $f = 9.89 \times 10^{14}$ Hz $KE_{max} = 0.90$ eV	$f_t = \frac{hf - KE_{max}}{h}$ $f_t = \frac{(6.63 \times 10^{-34}\ \text{J•s})(9.89 \times 10^{14}\ \text{Hz}) - (0.90\ \text{eV})(1.60 \times 10^{-19}\ \text{J/eV})}{6.63 \times 10^{-34}\ \text{J•s}}$ $f_t = \boxed{7.72 \times 10^{14}\ \text{Hz}}$
496. $m_n = 1.675 \times 10^{-27}$ kg $\lambda = 5.6 \times 10^{-14}$ m	$v = \frac{h}{m\lambda} = \frac{6.63 \times 10^{-34}\ \text{J•s}}{(1.675 \times 10^{-27}\ \text{kg})(5.6 \times 10^{-14}\ \text{m})} = \boxed{7.1 \times 10^{6}\ \text{m/s}}$

Subatomic Physics

497. Z = 19 A = 39 atomic mass of K-39 = 38.963 708 u atomic mass of H = 1.007 825 u $m_n = 1.008\ 665$ u	$N = A - Z = 39 - 19 = 20$ $\Delta m = Z$ (atomic mass of H) + Nm_n − atomic mass of K-39 $\Delta m = 19(1.007\ 825) + 20\ (1.008\ 665\ \text{u}) – 38.963\ 708\ \text{u}$ $\Delta m = 19.148\ 675\ \text{u} + 20.173\ 300\ \text{u} - 38.963\ 708\ \text{u}$ $\Delta m = 0.358\ 267\ \text{u}$ $E_{bind} = (0.358\ 267\ \text{u})(931.50\ \text{MeV/u}) = \boxed{333.73\ \text{MeV}}$
498. For $^{107}_{47}$Ag: $Z = 47$ $A = 107$ atomic mass of Ag-107 = 106.905 091 u atomic mass of H = 1.007 825 u $m_n = 1.008\ 665$ u	$N = A - Z = 107 - 47 = 60$ Δm = Z(atomic mass of H) + Nm_n − atomic mass of Ag-107 $\Delta m = 47(1.007\ 825\ \text{u}) + 60(1.008\ 665\ \text{u}) - 106.905\ 091\ \text{u}$ $\Delta m = 47.367\ 775\ \text{u} + 60.519\ 900\ \text{u} - 106.905\ 091\ \text{u}$ $\Delta m = 0.982\ 584\ \text{u}$ $E_{bind} = (0.982\ 584\ \text{u})(931.50\ \text{MeV/u}) = 915.28\ \text{MeV}$
For $^{63}_{29}$Cu: $Z = 29$ $A = 63$ atomic mass of Cu-63 = 62.929 599 u	$N = A - Z = 63 - 29 = 34$ Δm = Z(atomic mass of H) + Nm_n − atomic mass of Cu-63 $\Delta m = 29(1.007\ 825\ \text{u}) + 34(1.008\ 665\ \text{u}) - 62.929\ 599\ \text{u}$ $\Delta m = 29.226\ 925\ \text{u} + 34.294\ 610\ \text{u} - 62.929\ 599\ \text{u}$ $\Delta m = 0.591\ 936\ \text{u}$ $E_{bind} = (0.591\ 936\ \text{u})(931.50\ \text{MeV/u}) = 551.39\ \text{MeV}$ The difference in binding energy is 915.28 MeV − 551.39 MeV = $\boxed{363.89\ \text{MeV}}$
499. $A = 58$ $Z = 28$ atomic mass of Ni-58 = 57.935 345 u atomic mass of H = 1.007 825 u $m_n = 1.008\ 665$ u	$N = A - Z = 58 - 28 = 30$ $\Delta m = Z$(atomic mass of H) + Nm_n − atomic mass of Ni-58 $\Delta m = 28(1.007\ 825\ \text{u}) + 30(1.008\ 665\ \text{u}) - 57.935\ 345\ \text{u}$ $\Delta m = 28.219\ 100\ \text{u} + 30.259\ 950\ \text{u} - 57.935\ 345\ \text{u}$ $\Delta m = \boxed{0.543\ 705\ \text{u}}$

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500. ${}^{212}_{84}\text{Po} \rightarrow ? + {}^{4}_{2}\text{He}$	$A = 212 - 4 = 208$ $Z = 84 - 2 = 82$ $? = \boxed{{}^{208}_{82}\text{Pb}}$
501. ${}^{16}_{7}\text{N} \rightarrow ? + {}^{0}_{-1}\text{e} + \overline{\nu}$	$A = 16 - 0 = 16$ $Z = 7 - (-1) = 8$ $? = \boxed{{}^{16}_{8}\text{O}}$
502. ${}^{147}_{62}\text{Sm} \rightarrow {}^{143}_{60}\text{Nd} + ? + \overline{\nu}$	$A = 147 - 143 = 4$ $Z = 62 - 60 = 2$ $? = \boxed{{}^{4}_{2}\text{He}}$
503. $m_i = 3.29 \times 10^{-3}$ g $m_f = 8.22 \times 10^{-4}$ g $\Delta t = 30.0$ s	$\frac{m_f}{m_i} = \frac{8.22 \times 10^{-4}\text{ g}}{3.29 \times 10^{-3}\text{ g}} = \frac{1}{4}$ If $\frac{1}{4}$ of the sample remains after 30.0 s, then $\frac{1}{2}$ of the sample must have remained after 15.0 s, so $T_{1/2} = \boxed{15.0\text{ s}}$.
504. $T_{1/2} = 21.6$ h $N = 6.5 \times 10^6$	$\lambda = \frac{0.693}{T_{1/2}} = \frac{0.693}{(21.6\text{ h})(3600\text{ s/h})} = 8.90 \times 10^{-6}\text{ s}^{-1}$ $\text{activity} = N\lambda = \frac{(8.9 \times 10^{-6}\text{ s}^{-1})(6.5 \times 10^6)}{3.7 \times 10^{10}\text{ s}^{-1}/\text{Ci}} = \boxed{1.5 \times 10^{-9}\text{ Ci}}$
505. $T_{1/2} = 10.64$ h	For the sample to reach $\frac{1}{2}$ its original strength, it takes 10.64 h. For the sample to reach $\frac{1}{4}$ its original strength, it takes 2(10.64 h) = 21.28 h. For the sample to reach $\frac{1}{8}$ its original strength, it takes 3(10.64 h) = $\boxed{31.92\text{ h}}$
506. $Z = 50$ $A = 120$ atomic mass of Sn-120 = 119.902 197 atomic mass of H = 1.007 825 u $m_n = 1.008\ 665$ u	$N = A - Z = 120 - 50 = 70$ $\Delta m = Z(\text{atomic mass of H}) + Nm_n - \text{atomic mass of Sn-120}$ $\Delta m = 50(1.007\ 825\text{ u}) + 70(1.008\ 665\text{ u}) - 119.902\ 197\text{ u}$ $\Delta m = 50.391\ 25\text{ u} + 70.606\ 55\text{ u} - 119.902\ 197\text{ u}$ $\Delta m = 1.095\ 60\text{ u}$ $E_{bind} = (1.095\ 60\text{ u})(931.50\text{ MeV/u}) = \boxed{1020.6\text{ MeV}}$

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507. For ${}^{12}_{6}C$:

$Z = 6$

$A = 12$

atomic mass of C-12 = 12.000 000 u

atomic mass of H = 1.007 825 u

$m_n = 1.008\ 665$ u

$N = A - Z = 12 - 6 = 6$

$\Delta m = Z$ (atomic mass of H) + Nm_n – atomic mass of C-12

$\Delta m = 6(1.007\ 825\ u) + 6(1.008\ 665u) - 12.000\ 000\ u$

$\Delta m = 6.046\ 95\ u + 6.051\ 99\ u - 12.000\ 000\ u$

$\Delta m = 0.098\ 94\ u$

$E_{bind} = (0.098\ 94\ u)(931.50\ MeV/u) = 92.163\ MeV$

For ${}^{16}_{8}O$:

$Z = 8$

$A = 16$

atomic mass of O-16 = 15.994 915

$N = A - Z = 16 - 8 = 8$

$\Delta m = Z$ (atomic mass of H) + Nm_n – atomic mass of O-16

$\Delta m = 8(1.007\ 825\ u) + 8(1.008\ 665u) - 15.994\ 915\ u$

$\Delta m = 8.0626\ u + 8.06932\ u - 15.994\ 915\ u$

$\Delta m = 0.1370\ u$

$E_{bind} = (0.1370\ u)(931.50\ MeV/u) = 127.62\ MeV$

The difference in binding energy is

$127.62\ MeV - 92.163\ MeV = \boxed{35.46\ MeV}$

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508. $A = 64$

$Z = 30$

atomic mass of Zn-64 = 63.929 144 u

atomic mass of H = 1.007 825 u

$m_n = 1.008\ 665$ u

$N = A - Z = 64 - 30 = 34$

$\Delta m = Z$(atomic mass of H) + Nm_n – atomic mass of Zn-64

$\Delta m = 30(1.007\ 825\ u) + 34(1.008\ 665\ u) - 63.929\ 144\ u$

$\Delta m = 30.234\ 750\ u + 34.294\ 610\ u - 63.929\ 144\ u$

$\Delta m = \boxed{0.600\ 216\ u}$

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509. $? \rightarrow {}^{131}_{54}Xe + {}^{0}_{-1}e + \overline{\nu}$

$A = 131 + 0 = 131$

$Z = 54 + (-1) = 53$

$? = \boxed{{}^{131}_{53}I}$

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510. ${}^{160}_{74}W \rightarrow {}^{156}_{72}Hf + ?$

$A = 160 - 156 = 4$

$Z = 74 - 72 = 2$

$? = \boxed{{}^{4}_{2}He}$

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511. $? \rightarrow {}^{107}_{52}Te + {}^{4}_{2}He$

$A = 107 + 4 = 111$

$Z = 52 + 2 = 54$

$? = \boxed{{}^{111}_{54}Xe}$

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512. $m_i = 4.14 \times 10^{-4}$ g

$m_f = 2.07 \times 10^{-4}$ g

$\Delta t = 1.25$ days

$\frac{m_f}{m_i} = \frac{2.07 \times 10^{-4}\ g}{4.14 \times 10^{-4}\ g} = \frac{1}{2}$

If $\frac{1}{2}$ of the sample remains after 1.25 days, then $T_{1/2} = \boxed{1.25\ days}$

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513. $T_{1/2} = 462$ days

For the sample to reach $\frac{1}{2}$ its original strength, it takes 462 days. For the sample to reach $\frac{1}{4}$ its original strength, it takes 2(462 days) = $\boxed{924 \text{ days}}$

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514. $T_{1/2} = 2.7$ y

$N = 3.2 \times 10^9$

$$\lambda = \frac{0.693}{T_{1/2}} = \frac{0.693}{(2.7 \text{ y})(3.156 \times 10^7 \text{ s/y})} = \boxed{8.1 \times 10^{-9} \text{ s}^{-1}}$$