Answers To Topic 1

Review Questions

1. 4
2. 2
3. 4
4. 3
5. 3
6. 2
7. 1 GJ
8. 6000 km
9. 2
10. 3
11. 3
12. 700 nm

13. $F = \frac{mv^2}{r} = \frac{\text{kg} \cdot (\text{m/s})^2}{\text{m}} = \frac{\frac{\text{kg} \cdot \text{m}^2}{\text{s}^2}}{\text{m}} = \frac{\text{kg} \cdot \text{m}}{\text{s}^2}$

14. $PE_s = \frac{1}{2}kx^2$

$k = \frac{2PE_s}{x^2} = \frac{\text{kg} \cdot \text{m}^2/\text{s}^2}{\text{m}^2} = \frac{\text{kg}}{\text{s}^2}$

15. 1

16. $\frac{v^2}{d} = \frac{(\text{m/s})^2}{\text{m}} = \frac{\text{m}^2/\text{s}^2}{\text{m}} = \frac{\text{m}}{\text{s}^2}$

17. 1

18. 1.6 cm

19. $52.5 \text{ cm}\left(\frac{1 \text{ m}}{100 \text{ cm}}\right) = 0.525 \text{ m or } 5.25 \times 10^{-1} \text{ m}$

20. 2 **21.** 0.4040 kg **22.** 2

23. 1 hr 15 min = 75 min, so $75 \text{ min}\left(\frac{60. \text{ s}}{1 \text{ min}}\right) = 4500 \text{ s} = 4.5 \times 10^3 \text{ s}$

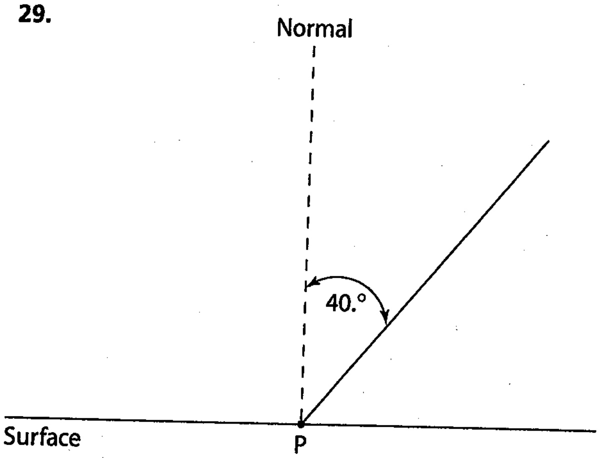
24. $18 \text{ min}\left(\frac{60. \text{ s}}{1 \text{ min}}\right) = 1100 \text{ s} = 1.1 \times 10^3 \text{ s}$

25. 2.5 N **26.** 1.4 N

27. (a) 25° (b) $\sin\theta = \frac{\text{opposite}}{\text{hypotenuse}}$ and $c = \frac{37. \text{ cm}}{\sin 25°} = 88 \text{ cm}$

28. (a) 25° (b) 0.42 (c) 0.91

29.



30. Using the scale in the drawing, 1.0 cm = 1.4 m, (a) 7.3 m (b) 3.6 m, or using a trigonometric function,

(a) $\sin\theta = \frac{\text{opposite}}{\text{hypotenuse}}$ and $c = \frac{6.1 \text{ m}}{\sin 60.°} = 7.0 \text{ m}$

(b) $\tan\theta = \frac{\text{opposite}}{\text{adjacent}}$ and $c = \frac{6.1 \text{ m}}{\tan 60.°} = 3.5 \text{ m}$

31. $\sin\theta = \frac{\text{opposite}}{\text{hypotenuse}}$, so $a = (50. \text{ m})\sin 30.° = 25 \text{ m}$

32. $\tan\theta = \frac{\text{opposite}}{\text{adjacent}}$,

so adjacent $= \frac{\text{opposite}}{\tan\theta} = \frac{35 \text{ m}}{\tan 20.°} = 96 \text{ m}$

33. 4
34. 3
35. 1
36. 4
37. 2
38. 1
39. 4
40. 4
41. 2
42. 13.3 m
43. 0.029 kg
44. 3
45. 2
46. 40.00 m

47. $A = lw = (41.6 \text{ cm})(2.3 \text{ cm}) = 96 \text{ cm}^2$

48. $A = lw = (13.2 \text{ m})(10.6 \text{ m}) = 140. \text{ m}^2$

$\frac{140. \text{ m}^2}{24 \text{ students}} = \frac{5.8 \text{ m}^2}{\text{student}}$; the answer is yes.

49. 2.1×10^{-2} m **50.** 1.5×10^3 kg **51.** 7.7×10^5 N

52. 4.98×10^2 s
53. 3
54. 3
55. 1
56. 2
57. 2
58. 2
59. 3
60. 3
61. 3
62. 3
63. 3
64. 3
65. 2
66. 4
67. 3

68. $\frac{7 \times 10^2 \text{ m/s}}{1 \times 10^{-3} \text{ m/s}} = 7 \times 10^5$

69. $\frac{1.7 \times 10^{17} \text{ W}}{100 \text{ W/bulb}} = 1.7 \times 10^{15}$ bulbs

70. 3

71. $\frac{10^{-19} \text{ C}}{10^{-31} \text{ kg}} = 10^{12}$ C/kg

72. $\frac{3.00 \times 10^8 \text{ m/s}}{3.31 \times 10^2 \text{ m/s}} = 10^6$

73. $\frac{10^{22} \text{ kg}}{10^{24} \text{ kg}} = 10^{-2}$

74. 1

75. Percent Error $= \frac{\text{absolute error}}{\text{accepted value}} \times 100$

$= \frac{0.25 \times 10^8 \text{ m/s}}{2.25 \times 10^8 \text{ m/s}} \times 100 = 11\%$

76. Percent Error $= \frac{\text{absolute error}}{\text{accepted value}} \times 100$

$= \frac{0.2 \text{ m/s}^2}{9.81 \text{ m/s}^2} \times 100 = 2\%$

77. Range = 4.73 min − 4.07 min = 0.66 min

x_i (min)	f_i	$x_i f_i$ (min)	$x_i - \bar{x}$ (min)	$(x_i - \bar{x})^2$ (min²)	$(x_i - \bar{x})^2 f_i$ (min²)
4.66	1	4.66	0.32	0.1024	0.1024
4.73	1	4.73	0.39	0.1521	0.1521
4.51	1	4.51	0.17	0.0289	0.0289
4.32	1	4.32	−0.02	0.0004	0.0004.
4.17	1	4.17	−0.17	0.0289	0.0289
4.15	1	4.15	−0.19	0.0361	0.0361
4.12	1	4.12	−0.22	0.0484	0.0484
4.07	1	4.07	−0.27	0.0729	0.0729
	$\Sigma f_i = 8$	$\Sigma x_i f_i = 34.73$			$\Sigma(x_i - \bar{x})^2 f_i = 0.4701$

The chart at left is for instructional purposes. Students may determine values using a scientific calculator.

78. $\bar{x} = \frac{34.73 \text{ min}}{8} = 4.34 \text{ min}$

79. $\sigma = \sqrt{\frac{0.4701 \text{ min}^2}{8}} = 0.24 \text{ min}$

80. Range = 96°F − 63°F = 33 °F. The chart below is for instructional purposes. Students may determine values using a scientific calculator.

x_i (°F)	f_i	$x_i f_i$ (°F)	$x_i - \bar{x}$ (°F)	$(x_i - \bar{x})^2$ (°F)^2	$(x_i - \bar{x})^2 f_i$ (°F)^2
63	5	315	−16	256	1280.
70.	3	210.	−9	81	243
78	4	312	−1	1	4
79	3	237	0	0	0
80.	6	480.	1	1	6
84	4	336	5	25	100.
96	5	480.	17	289	1445
	$\Sigma f_i = 30.$	$\Sigma x_i f_i = 2370.$			$\Sigma(x_i - \bar{x})^2 f_i = 3078$

81. $\bar{x} = \frac{2370. \text{ °F}}{30.} = 79.0\text{°F}$

82. $\sigma = \sqrt{\frac{3078 \text{ °F}^2}{30.}} = 10.1 \text{ °F}$

83. Range = 26 cm − 18 cm = 8 cm. The chart below is for instructional purposes. Students may determine values using a scientific calculator.

x_i (cm)	f_i	$x_i f_i$ (cm)	$x_i - \bar{x}$ (cm)	$(x_i - \bar{x})^2$ (cm^2)	$(x_i - \bar{x})^2 f_i$ (cm^2)
18	6	108	−3	9	54
19	4	76	−2	4	16
20.	4	80.	−1	1	4
21	3	63	0	0	0
24	5	120.	3	9	45
26	3	782	5	25	75
	$\Sigma f_i = 25$	$\Sigma x_i f_i = 525$			$\Sigma(x_i - \bar{x})^2 f_i = 194$

84. $\bar{x} = \frac{525 \text{ cm}}{25} = 21.0 \text{ cm}$

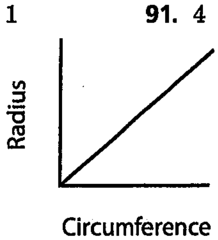
85. $\sigma = \sqrt{\frac{194 \text{ cm}^2}{25}} = 2.8 \text{ cm}$

86. Nonlinear horizontal scale, skipped 300 on vertical scale, (m) as a unit not labeled on the vertical axis, dependent variable should be first in the title.

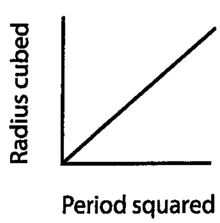
87. 4 **88.** 3 **89.** 3

90. 1 **91.** 4

92.



93.



94. (a) $F = \frac{mv^2}{r}$

$Fr = mv^2$

$r = \frac{mv^2}{F}$

(b) $A = \pi r^2$

$r^2 = \frac{A}{\pi}$

$r = \sqrt{\frac{A}{\pi}}$

(c) $C = 2\pi r$

$r = \frac{C}{2\pi}$

(d) $F = G\frac{m_1 m_2}{r^2}$

$Fr^2 = Gm_1 m_2$

$r = \sqrt{\frac{Gm_1 m_2}{F}}$

95. (a) $\bar{v} = \frac{d}{t}$

$d = \bar{v}t$

(b) $P = \frac{Fd}{t}$

$Pt = Fd$

$d = \frac{Pt}{F}$

(c) $v_f^2 = v_i^2 + 2ad$

$2ad = v_f^2 - v_i^2$

$d = \frac{v_f^2 - v_i^2}{2a}$

$R = \frac{V}{I}$

97. (a) $RI = V$

$I = \frac{V}{R}$

$W = VIt$

(b) $I = \frac{W}{Vt}$

$P = I^2 R$

(c) $I^2 = \frac{P}{R}$

$I = \sqrt{\frac{P}{R}}$

98. $3.335\,640\,95 \times 10^{-9}$ s

99. 2

100. 10.°

96. (a) $KE = \frac{1}{2}mv^2$

$2\,KE = mv^2$

$v^2 = \frac{2KE}{m}$

$v = \sqrt{\frac{2KE}{m}}$

(b) $p = mv$

$v = \frac{p}{m}$

(c) $n = \frac{c}{v}$

$v = \frac{c}{n}$

101. $\sin\theta = \frac{\text{opposite}}{\text{hypotenuse}}$ so opposite = hypotenuse($\sin\theta$) = (1.4 m)sin10.° = 0.24 m

102. $A = A_{triangle} + A_{rectangle} + A_{triangle}$

$A = \frac{1}{2}bh + bh + \frac{1}{2}bh$

$A = \frac{1}{2}(2.0\text{ s})(10.\text{ m/s}) + (6.0\text{ s})(10.\text{ m/s}) + \frac{1}{2}(2.0\text{ s})(5\text{ s})$

$A = 70\text{ m}$

103. slope $= \frac{\Delta v}{\Delta t} = \frac{5.0\text{ m/s}}{2.0\text{ s}} = 2.5\text{ m/s}^2$

Answers To Topic 2

Review Questions

1. 1
2. 4
3. $c^2 = a^2 + b^2$

$c = \sqrt{a^2 + b^2} = \sqrt{(15\text{ m})^2 + (15\text{ m})^2} = 21\text{ m}$

4. 3
5. 1
6. 4
7. 3
8. 4
9. $a = \frac{\Delta v}{t}$

$t = \frac{\Delta v}{a} = \frac{28\text{ m/s} - 8.0\text{ m/s}}{2.0\text{ m/s}^2} = 10.\text{ s}$

10. 4
11. D
12. 1
13. 2
14. $v_f^2 = v_i^2 + 2ad = 2(3.2\text{ m/s}^2)(40.\text{ m})$

$v_f = 16\text{ m/s}$

15. $a = \frac{\Delta v}{t} = \frac{25\text{ m/s} - 10.\text{ m/s}}{5.0\text{ s} - 3.0\text{ s}} = 7.5\text{ m/s}^2$
16. 18 m/s
17. The area under the curve is equal to the distance traveled.

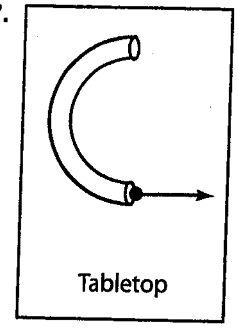
$A = A_{\text{triangle}} + A_{\text{rectangle}}$

$A_{\text{triangle}} = \frac{1}{2}bh = \frac{1}{2}(1.0\text{ s})(10.\text{ m/s}) = 5.0\text{ m}$

$A_{\text{rectangle}} = bh = (2.0\text{ s})(10.\text{ m/s}) = 20.\text{ m}$

$A = 25\text{ m}$

18. AB
19. 3
20. $\bar{v} = \frac{d}{t} = \frac{3.0\text{ m} - 2.0\text{ m}}{2.0\text{ s} - 1.0\text{ s}} = 1.0\text{ m/s}$
21. 3
22. 3
23. 3
24. C
25. B
26. C
27. A
28. 2
29. 2
30. 4
31. 4
32. 3 m
33. 2 s to 3 s
34. 1
35. 3 s to 4 s
36. 4
37. 3
38. 2
39. $v_f = v_i + at = (9.81\text{ m/s}^2)(3.00\text{ s}) = 29.4\text{ m/s}$
40. 1
41. 3
42. 1
43. 4
44. 1
45. 3
46. 2
47. 2
48. 3
49. 1
50. 2
51. $A_y = A\sin\theta = (300.\text{ N})(\sin 60.°) = 260\text{ N}$
52. 2
53. 4
54. 4
55. 1
56. 2
57.



58. 3
59. 3
60. 4
61. 4
62. 2
63. $a = \frac{F_{\text{net}}}{m} = \frac{10.0\text{ N}}{20.0\text{ kg}} = 0.500\text{ m/s}^2$
64. 3
65. 1
66. 4
67. 4
68. 40. N
69. 4
70. For every action force there is an equal but opposite reaction force.
71. 2
72. 3
73. 2
74. 3
75. 1
76. 2
77. B
78. Both arrows take the same amount of time to strike the plane.
79. $d = v_i t + \frac{1}{2}at^2$

$t = \sqrt{\frac{2d}{a}} = \sqrt{\frac{2(45\text{ m})}{9.81\text{ m/s}^2}} = 3.0\text{ s}$

80. 3
81. 3
82. 2
83. 1
84. $A_x = A\cos\theta = (150.\text{ m/s})(\cos 30.°) = 130.\text{ m/s}$
85. 1
86. 1
87. $a_{\text{horizontal}} + 0.0\text{ m/s}^2$ and $a_{\text{vertical}} = 9.81\text{ m/s}^2$
88. $a = \frac{v^2}{r} = \frac{(6.0\text{ m/s})^2}{3.0\text{ m}} = 12\text{ m/s}^2$, directed toward the center of curvature
89. $F = \frac{mv^2}{r} = \frac{(2.0\text{ kg})(6.0\text{ m/s})^2}{3.0\text{ m}} = 24\text{ N}$
90. 2
91. 1
92. 4
93. 3
94. D
95. A
96. 3
97. 2
98. 1
99. 3
100. S
101. Q
102. 1
103. 3
104. 3
105. $\frac{F}{9}$
106. 4
107. 3
108. B
109. $g = \frac{F_g}{m}$

$F_g = mg = (5.00\text{ kg})(9.81\text{ m/s}^2) = 49.1\text{ N}$

110. 4
111. acceleration due to gravity or gravitational field strength
112. $g = \frac{F_g}{m} = \frac{96\text{ N}}{60.\text{ kg}} = 1.6\text{ m/s}^2$
113. 4
114. 2
115. 3
116. 3
117. 2
118. 1
119. 2
120. A and D

121. $F_f = \mu F_N$
$F_f = (0.30)(25\text{ N})$
$F_f = 7.5\text{ N}$

122. 2.5 N

123. The crate is accelerating because a net force is acting on it.

124. 1 125. 2

126. $F_f = \mu F_N$
$F_f = (.15)(10.\text{ kg})(9.81\text{ m/s}^2)$
$F_f = 15\text{ N}$ *or* 14.7 N

127. 10. N

128. $g = \frac{F_g}{m}$
$F_g = mg = (5.0\text{ kg})(9.81\text{ m/s}^2) = 49\text{ N}$

129. The normal force is equal in magnitude to the cart's weight, but opposite in direction.

130. $F_f = \mu F_N$
$\mu = \frac{F_f}{F_N} = \frac{10.\text{ N}}{49\text{ N}} = 0.20$

131. $F_f = \mu F_N$
$F_N = \frac{F_f}{\mu} = \frac{5.2\text{ N}}{0.30} = 17\text{ N}$; in this case, the weight equals the normal force.

132. 3 133. 1 134. 2
135. 3 136. 4 137. 3

138. $J = F_{net}t$
$F_{net} = \frac{J}{t} = \frac{6.0\text{ N}\cdot\text{s}}{3.0\text{ s}} = 2.0\text{ N}$ east

139. 2 140. 3 s to 4 s

141. + 3 N · s 142. 1

143. $J = \Delta p = m\Delta v$
$\Delta v = \frac{J}{m} = \frac{30.0\text{ N}\cdot\text{s}}{5.00\text{ kg}} = 6.00\text{ m/s}$
Therefore, the final speed of the mass could be 94 m/s or 106 m/s.

144. 2

145. $p_{before} = p_{after}$
$m_a v_{a_i} = m_b v_{b_i} = p_{after}$
$(2.0\text{ kg})(6.0\text{ m/s}) + (3.0\text{ kg})v_{b_i} = 0\text{ kg}\cdot\text{m/s}$
$(3.0\text{ kg})v_{b_i} = -12\text{ kg}\cdot\text{m/s}$
$v_{b_i} = -4.0\text{ m/s}$

146. $p_{before} = p_{after}$
$m_a v_{a_i} + m_b v_{b_i} = (m_a + m_b)v_f$
$(0.180\text{ kg})(0.80\text{ m/s}) + (0.100\text{ kg})(0.0\text{ m/s}) =$
$(0.180\text{ kg} + 0.100\text{ kg})v_f$
$v_f = 0.51\text{ m/s}$ to the right

147. 1

Regents Practice Questions

1. 2 2. 3 3. 1
4. 4 5. 3 6. 1
7. 4 8. 3 9. 2
10. 2 11. 4 12. 3
13. 1 14. 3 15. 3
16. 1 17. 1 18. 2
19. 3 20. 2 21. 2
22. 3 23. 3 24. 3
25. 4 26. 1 27. 4
28. 2 29. 2 30. 1
31. 4 32. 3 33. 1
34. 1 35. 1 36. 3
37. 1 38. 4 39. 2
40. 4 41. 4 42. 3
43. 3 44. 2 45. 3
46. 4 47. 3 48. 2
49. 4 50. 3 51. 3

52. 3

53. 30.° ± 2°

54. 140 m ± 20 m

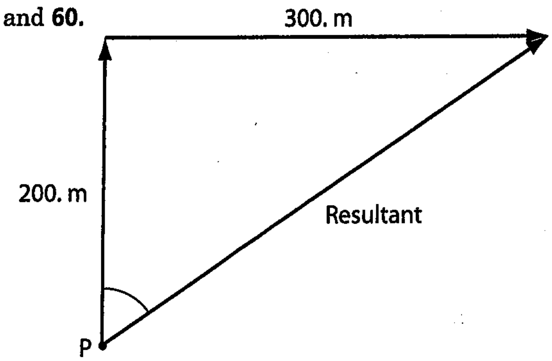
55. 240 m

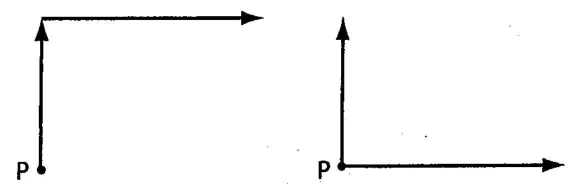
56. $d = v_i t + \frac{1}{2}at^2$
$t = \sqrt{\frac{2d}{a}} = \sqrt{\frac{2(240\text{ m})}{9.81\text{ m/s}^2}} = 7.0\text{ s}$

57. $v_f = v_i = at = (9.81\text{ m/s}^2)(7.0\text{ s}) = 69\text{ m/s}$ or
$v_f = \sqrt{v_i^2 + 2ad} = \sqrt{2(9.81\text{ m/s}^2)(240\text{ m})} = 69\text{ m/s}$

58. 1

59. and 60.





correct vector sequence

incorrect vector sequence

61. 361 m ± 15 m

62. 56° ± 2°

63. $v_f = v_i + at$
$t = \frac{v_f - v_i}{a} = \frac{0.0\text{ m/s} - 20.\text{ m/s}}{9.81\text{ m/s}^2} = 2.0\text{ s}$

64. Because the stone averages 10. m/s while it is moving upwards,
$d = \bar{v}t = (10.\text{ m/s})(2.0\text{ s}) = 20.\text{ m}$ or
$d = v_i t + \frac{1}{2}at^2$
$= (20.\text{ m/s})(2.0\text{ s}) + \frac{1}{2}(-9.81\text{ m/s}^2)(2.0\text{ s})^2$
$= 40.\text{ m} - 20.\text{ m} = 20.\text{ m}$

65. The time it takes for the stone to fall to the level of the student equals its time of rise, 2.0 seconds, because neglecting air resistance the force of gravity on the stone is constant.

66. The speed of the stone at the time it returns to the level of the student is 20. m/s because the force of gravity acting on the stone is constant. However,

the stone is traveling in the opposite direction so its velocity is $-20.$ m/s, or 20. m/s downward.

67. In a 6.0-second time interval, the stone rises for 2.0 seconds as determined in question 62, and falls for 4.0 seconds, assuming the cliff is high enough so that the stone does not hit the ground before 4.0 seconds has elapsed.

$v_f = v_i = at = 0.0 \text{ m/s} + (-9.81 \text{ m/s}^2)(4.0 \text{ s})$

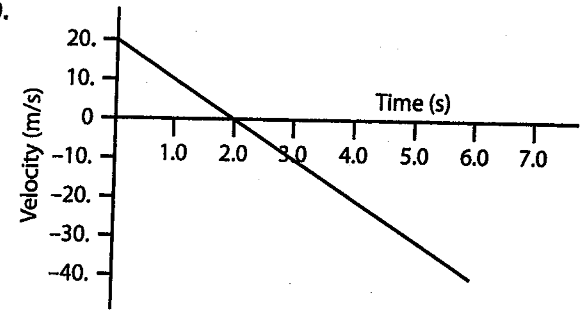
$= 39$ m/s downward, or -39 m/s

68. $d = \frac{1}{2}at^2$ (from rest)

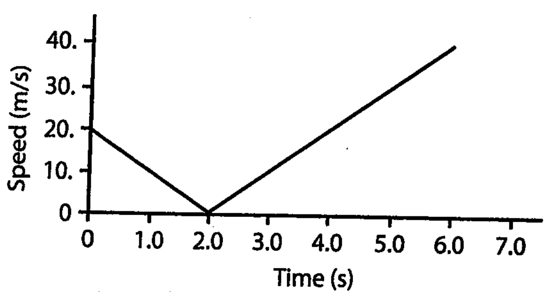
$d = \frac{1}{2}(-9.81 \text{ m/s}^2)(4.0 \text{ s})^2 = -78 \text{ m}$

The stone falls 78 meters downward from its highest point, or 58 meters below the position of the student.

69.



70.



71. $a = \frac{\Delta v}{t} = \frac{40. \text{ m/s}}{20. \text{ s}} = 2.0 \text{ m/s}^2$

72. The area under the curve is equal to the distance traveled.

$A = A_{\text{triangle}} + A_{\text{rectangle}}$

$A_{\text{triangle}} = \frac{1}{2}bh = \frac{1}{2}(20. \text{ s})(40. \text{ m/s}) = 400 \text{ m}$

$A_{\text{rectangle}} = bh = (2.0 \text{ s})(40. \text{ m/s}) = 800. \text{ m}$

$A = 1200 \text{ m}$

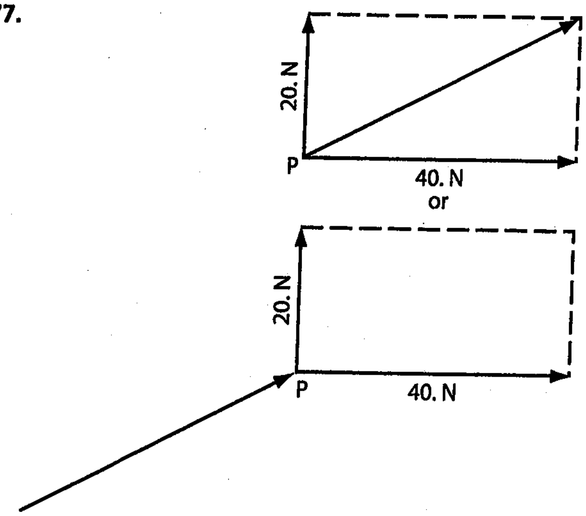
73. 20. m/s

74. decelerating to rest

75. BC

76. 5.0 N ± 0.2 N

77.



78. 45 N ± 2 N

79. 27° ± 2°

80. $a = \frac{F_{\text{net}}}{m} = \frac{45 \text{ N}}{10. \text{ kg}} = 4.5 \text{ m/s}^2$

81. $c^2 = a^2 + b^2$

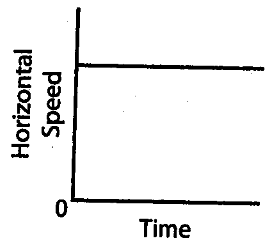
$c = \sqrt{a^2 + b^2} = \sqrt{(9.0 \text{ m/s})^2 + (9.0 \text{ m/s})^2} = 13 \text{ m/s}$

82. $\bar{v} = \frac{d}{t}$

$d = \bar{v}t = (9.0 \text{ m/s})(1.84 \text{ s}) = 17 \text{ m}$

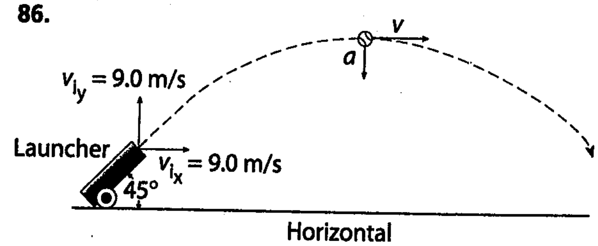
83. The vertical acceleration is a constant, -9.81 m/s^2.

84.



85. As the ball rises the vertical component of its velocity decreases and the horizontal component of its velocity remains the same.

86.



87. See question 86.

88. 0.0 N

89. $F = \frac{mv^2}{r} = \frac{(1.00 \times 10^3 \text{ kg})(20.0 \text{ m/s})^2}{100. \text{ m}}$

$= 4.00 \times 10^3$ N directed toward the center of curvature

90. $\bar{v} = \frac{d}{t}$

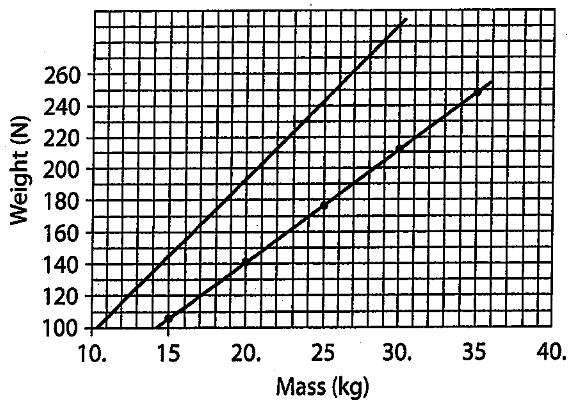
$d = \bar{v}t = (20.0 \text{ m/s})(20.0 \text{ s}) = 400. \text{ m}$

91. The magnitude of the car's centripetal acceleration from *D* to *A* is twice as great as the magnitude of its centripetal acceleration from *B* to *C*.

92. Because the car is moving at constant speed, the magnitude of its momentum is always the same.

93. The magnitude of the centripetal acceleration is the same because it is not dependent on mass.

94. **Weight vs. Mass**



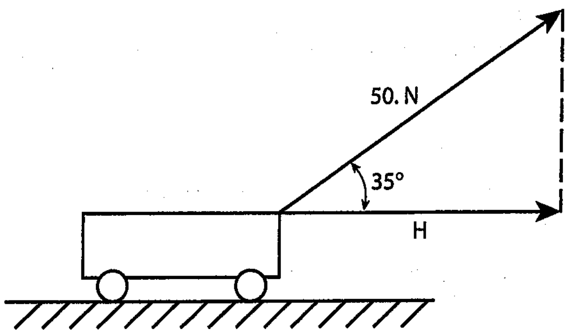
95. See question 94.

96. See question 94.

97. $g = \frac{F_g}{m} = \frac{170.\ \text{N}}{24\ \text{kg}} = 7.1\ \text{m/s}^2$

98. See question 94.

99.



100. See question 99.

101. 41 N ± 3 N

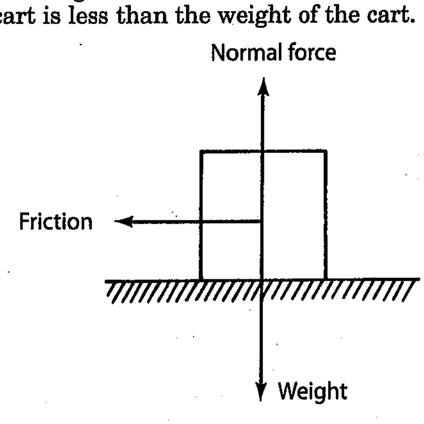
102. 41 N ± 3 N

103. $F_f = \mu F_N$

$F_N = \frac{F_f}{\mu} = \frac{41\ \text{N}}{0.68} = 60.\ \text{N}$

104. The magnitude of the normal force acting on the cart is less than the weight of the cart.

105.



106. $a = \frac{F_{net}}{m}$ and $g = \frac{F_g}{m}$, so $m = \frac{F_g}{g}$

$a = \frac{F_{net}g}{F_g} = \frac{(2.4\ \text{N})(9.81\ \text{m/s}^2)}{4.2\ \text{N}} = 5.6\ \text{m/s}^2$

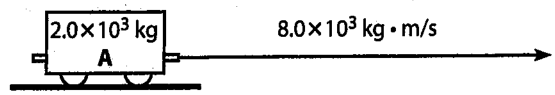
107. $F_f = \mu F_N$

$\mu = \frac{F_f}{F_N} = \frac{2.4\ \text{N}}{4.2\ \text{N}} = 0.57$

108. $p = mv = (2.00 \times 10^3\ \text{kg})(4.0\ \text{m/s})$

$= 8.0 \times 10^3\ \text{kg} \cdot \text{m/s}$

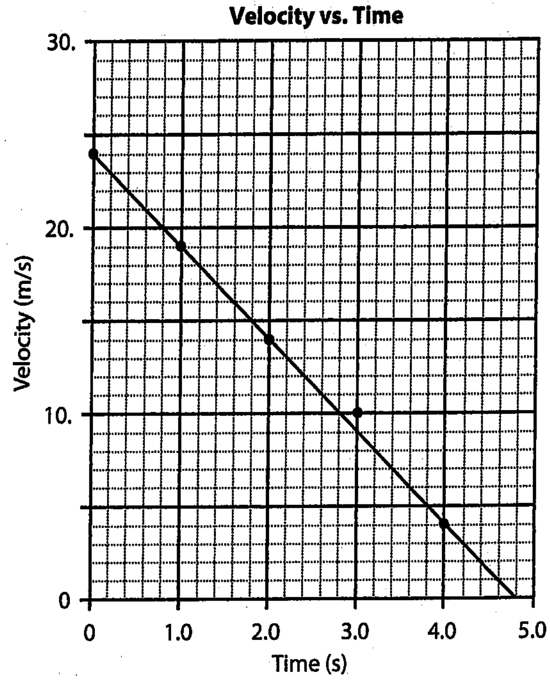
109.



The vector should be 8.0 cm long.

110. Momentum is conserved. The initial momentum of the system was $8.0 \times 10^3\ \text{kg} \cdot \text{m/s} + (-6.0 \times 10^3\ \text{kg} \cdot \text{m/s}) = +2.0 \times 10^3\ \text{kg} \cdot \text{m/s}$, so the final momentum of the system is $+2.0 \times 10^3\ \text{kg} \cdot \text{m/s}$.

111. **Velocity vs. Time**



112. See question 111.

113. $a = \frac{\Delta v}{t} = \frac{1\ \text{m/s} - 21\ \text{m/s}}{4.6\ \text{s} - 0.6\ \text{s}} = -5.0\ \text{m/s}^2\ (\pm 0.3\ \text{m/s}^2)$

114. $A_{triangle} = \frac{1}{2}bh = \frac{1}{2}(4.8\ \text{s})(24\ \text{m/s}) = 58\ \text{m}$

115. $\Delta p = m\Delta v = (1500\ \text{kg})(-24.0\ \text{m/s})$

$= -3.6 \times 10^4\ \text{kg} \cdot \text{m/s}$

116. $F_{net}t = \Delta p$

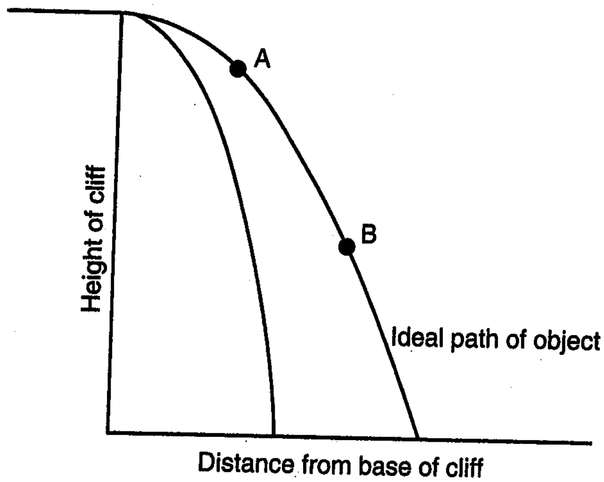
$F = \frac{\Delta p}{t} = \frac{-3.6 \times 10^4\ \text{kg} \cdot \text{m/s}}{4.8\ \text{s}} = -7.5 \times 10^3\ \text{N}$

117. The impulse is equal to the change in momentum.

118. The magnitude of the horizontal component of the object's velocity is the same at points *A* and *B*.

119. The magnitude of the vertical component of the object's velocity at point *A* is less than it is at point *B*.

120.



121. 0.5 m/s

122. $\bar{v} = \frac{d}{t} = \frac{60.\ \text{km}}{4.0\ \text{h}} = 15\ \text{km/h}$

123. 1 124. 1 125. 2

126. 4 127. 4 128. 3

129. 4 130. 50.0 N

131. 2 132. 1

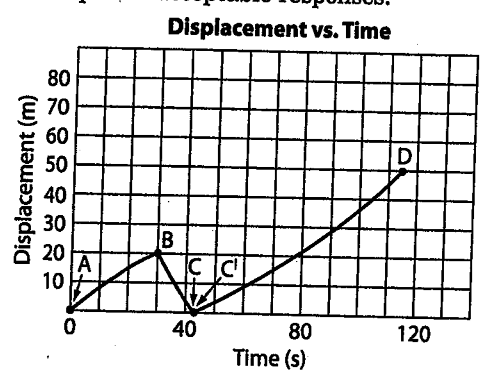
133. Block *A* has a mass of 1 kilogram and block *B* has a mass of 2 kilograms.

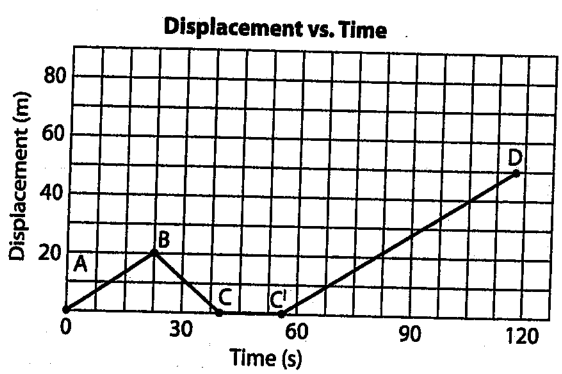
134. $A_x = A \cos \theta = (100.\ \text{N})(\cos 30.°) = 86.6\ \text{N}$
In equilibrium $F_{net} = 0$
$F_{net} = F_x + F_f = 0$ and $F_f = 86.6\ \text{N}$ (magnitude)

135. 2 136. 1 137. 75 m

138. $6.0\ \text{m/s}^2$ 139. 3 140. 1

141. Examples of acceptable responses:





142. See question 141.

143. Range: 0.50 s to 1.00 s

144. 0.7615 s and 0.76 s

145. $\sigma = 0.11\ \text{s}$

146. 32

147. 80.%

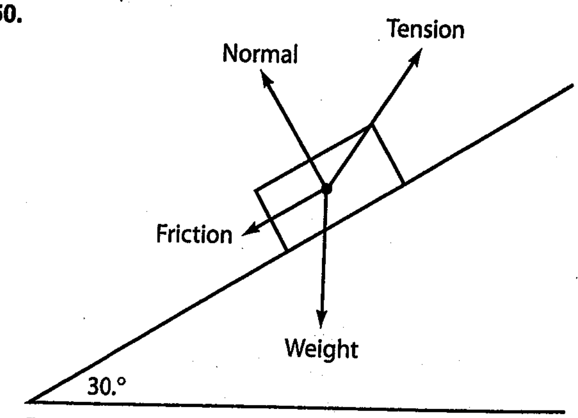
148. $d = \frac{1}{2}at^2$ (from rest)

$a = \frac{2d}{t^2} = \frac{2(2.848\ \text{m})}{(0.7615\ \text{s})^2} = 9.823\ \text{m/s}^2$

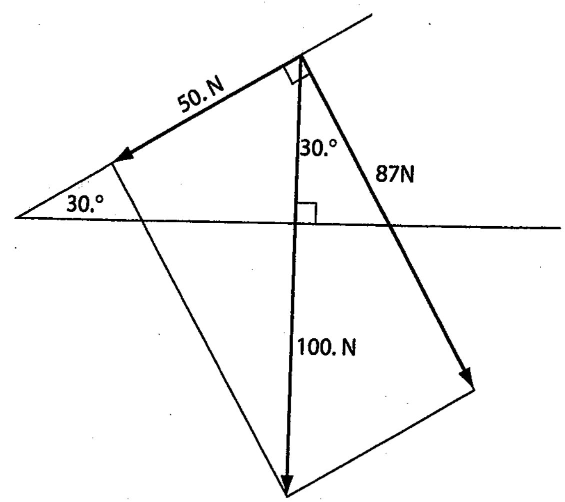
149. $\text{Percent Error} = \frac{\text{absolute error}}{\text{accepted value}} \times 100$

$= \frac{0.01\ \text{m/s}^2}{9.81\ \text{m/s}^2} \times 100 = 0.1\%$

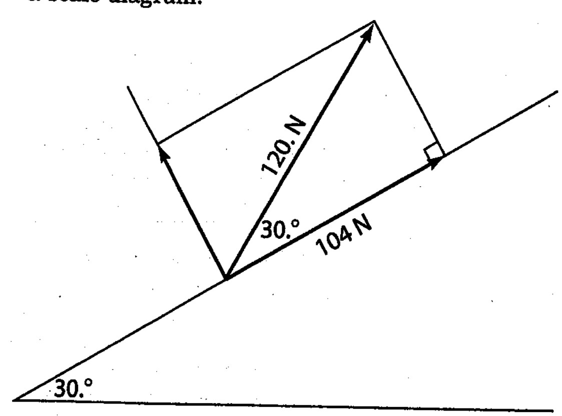
150.



151. $F_{g_{parallel}} = F_g \sin \theta = (100.\ \text{N})(\sin 30.°) = 50.0\ \text{N}$, or make a scale diagram.



152. $F_x = F \cos \theta = (120.\ \text{N})(\cos 30.°) = 104\ \text{N}$, or make a scale diagram.



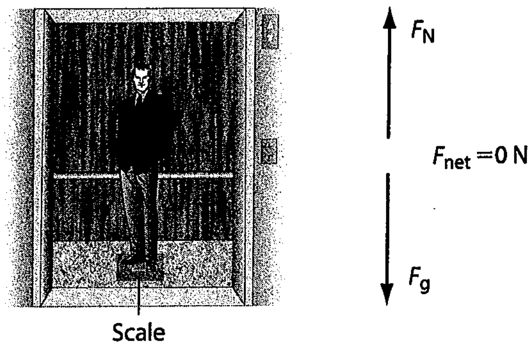
153. $a = \frac{F_{net}}{m}$ and $g = \frac{F_g}{m}$

$F_{net} = 104\ \text{N} - 50.\ \text{N} - 10.\ \text{N} = 44\ \text{N}$

$m = \frac{F_g}{g} = \frac{100.\ \text{N}}{9.81\ \text{m/s}^2} = 10.2\ \text{kg}$

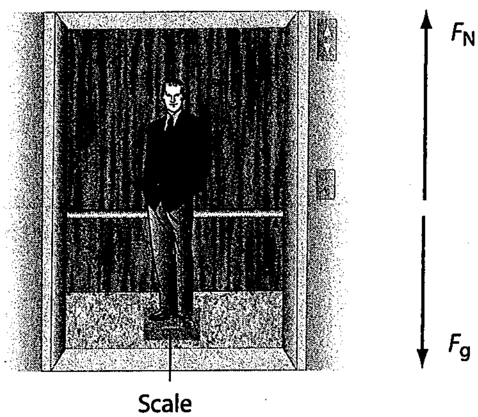
$a = \frac{44\ \text{N}}{10.2\ \text{kg}} = 4.3\ \text{m/s}^2$ up the incline

154.



155. $F_{net} = 0$ N

156.



157. The reading on the scale when the elevator is accelerating upward is greater than when the elevator is stationary.

158. $\bar{v}_x = \frac{d_x}{t}$ and $t = \frac{t_1 + t_2 + t_3}{3}$

$$= \frac{0.453\text{ s} + 0.347\text{ s} + 0.390\text{ s}}{3} = 0.397\text{ s}$$

$$\bar{v}_x = \frac{1.00\text{ m}}{0.397\text{ s}} = 2.52\text{ m/s}$$

159. $d = \frac{1}{2}at^2$ from rest

$$t = \sqrt{\frac{2d_y}{a_y}} = \sqrt{\frac{2(0.926\text{ m})}{9.81\text{ m/s}^2}} = 0.434\text{ s}$$

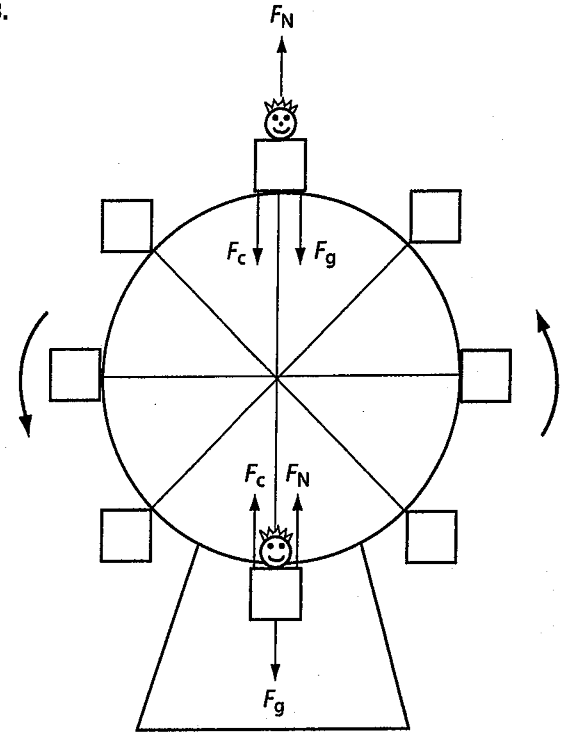
160. $\bar{v}_x = \frac{d_x}{t}$

$$d_x = \bar{v}_x t = (2.52\text{ m/s})(0.434\text{ s}) = 1.09\text{ m}$$

161. Although the time was recorded to the nearest thousandth of a second, the broad range in the values indicates that more data should have been taken. The calculated horizontal speed of the car represents an average over an interval; the car was actually traveling slower when it was projected from the edge of the tabletop.

162. (a) The car would have a greater initial potential energy and, consequently, a greater final kinetic energy and horizontal speed. (b) Releasing the car from a greater height on the elevated track would have no effect on the time required for the car to hit the floor once it left the tabletop. The time of fall depends only on the height of the tabletop. (c) With the greater horizontal speed noted in (a), the car would travel a greater horizontal distance after it was projected from the tabletop.

163.



164. See question 163.

165. $F_{net} = F_c = F_N - F_g$

166. $F_{net} = -F_c = F_N - F_g$

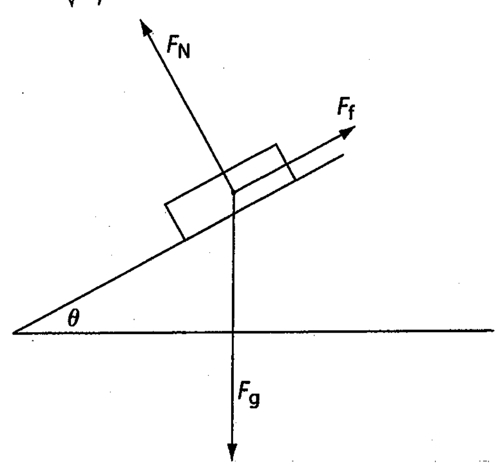
167. $F_c = F_g$

$$\frac{mv^2}{r} = \frac{Gm_1m_2}{r^2}$$

$$\frac{v^2}{r} = \frac{Gm_E}{r^2}$$

$$v = \sqrt{\frac{Gm_E}{r}}$$

168.



169. $F_{\parallel} = F_g \sin\theta$

$F_{\perp} = F_g \cos\theta$

170. $F_f = \mu F_N$

$$\mu = \frac{F_g \sin\theta}{F_g \cos\theta} = \tan\theta$$

171. Julia is correct. Average speed, a scalar quantity, is total distance traveled divided by time of travel. Velocity is a vector quantity. As an object moves in a circular path, its velocity continually changes due to a change in direction of travel, although the object may be moving at a constant speed.

172. All of the washers could be collectively massed using the triple-beam balance. Dividing by the number of washers would yield the average mass of a washer. It is the weight of the suspended washers that provides the centripetal force acting on the moving rubber stopper. Substituting the mass in kilograms of the appropriate number of washers into the formula $F_g = mg$ yields the value of the centripetal force.

173. $F_c = \frac{mv^2}{r}$

$\bar{v} = \frac{d}{t} = \frac{2\pi r}{T}$

substituting

$$F_c = \frac{m\left(\frac{2\pi r}{T}\right)^2}{r}$$

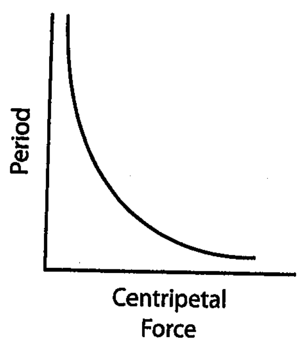
$$F_c = \frac{4\pi^2 mr}{T^2}$$

174. a pair of goggles for each student and a meter stick to measure the radius

175. It is difficult to note exactly one revolution for a rapidly moving object. Significant error can be introduced in starting and stopping the watch due to human reaction time. It is preferable to spread that error over thirty revolutions to minimize its effects.

176. Constant quantities: mass of stopper, radius of curvature. Column headings might be Number of Washers, Magnitude of Centripetal Force (N), Time for Thirty Revolutions (s), and Period of Revolution(s).

177.



178. They did not determine (a) the relationship between the magnitude of the centripetal force and the mass of a moving object or (b) the relationship between the magnitude of the centripetal force and the radius of curvature of the path of a moving object.

179. $F_f = \mu F_N \quad F_N = mg \quad F_c = \frac{mv^2}{r}$ [1]

$\mu = \frac{v^2}{rg}$ [1]

$\mu = \frac{(20.\ \text{m/s})^2}{(80.\ \text{m})(9.81\ \text{m/s}^2)}$ [1]

$\mu = 0.51$ [1]

or

$F_c = ma_c \quad a_c = \frac{v^2}{r}$

$F_c = \frac{mv^2}{r} = \frac{(1600\ \text{kg})(20.\ \text{m/s}^2)}{80.\ \text{m}} = 8.0 \times 10^3\ \text{N}$ [1]

$F_N = mg = (1600\ \text{kg})(9.81\ \text{m/s}^2) = 1.6 \times 10^4\ \text{N}$ [1]

$F_f = F_c$ [1]

$F_f = \mu F_N \quad \mu = \frac{F_f}{F_N} = \frac{8.0 \times 10^3\ \text{N}}{1.6 \times 10^4\ \text{N}} = 0.50$ [1]

180. Changing the mass of the car would have no effect on the maximum speed at which it could round the curve.

ANSWERS TO TOPIC 3

Review Questions

1. 4 **2.** 2 **3.** 2
4. 80. N **5.** 3 **6.** 100. J
7. 4 **8.** 3

9. $W = Fd$ and $\bar{v} = \frac{d}{t}$, therefore
$W = F\bar{v}t = (20.0\ \text{N})(4.0\ \text{m/s})(6.0\ \text{s}) = 480\ \text{J}$

10. 0 N

11. $W = Fd = (8.0\ \text{N})(3.0\ \text{m}) = 24\ \text{J}$

12. 4.0 m

13. 3 **14.** 3 **15.** 4
16. 20. m/s **17.** 3 **18.** 3
19. 1.2×10^3 W **20.** 3

21. $P = \frac{Fd}{t}$ and $t = \frac{Fd}{P} = \frac{(5.0 \times 10^2\ \text{N})(5.0\ \text{m})}{250\ \text{W}} = 10.\ \text{s}$

22. 4

23. $P = \frac{W}{t} = \frac{Fd}{t} = \frac{(500.\ \text{N})(18\ \text{m})}{50.0\ \text{s}} = 180\ \text{W}$

24. 1

25. $P = F\bar{v}$

$\bar{v} = \frac{P}{F} = \frac{2.00 \times 10^3\ \text{W}}{4.0 \times 10^2\ \text{N}} = 5.0\ \text{m/s}$

26. 2 **27.** 4 **28.** 3
29. 2 **30.** 4 **31.** 3
31. 3 **32.** 2

33. $\Delta PE = mg\Delta h = (5.00\ \text{kg})(9.81\ \text{m/s}^2)(2.00\ \text{m}) = 98.1\ \text{J}$

34. 1 **35.** 4 **36.** 2
37. 3 **38.** 4

39. $F = kx = (25\ \text{N/m})(0.25\ \text{m}) = 6.3\ \text{N}$

40. 4 **41.** 4 **42.** 4
43. 4

44. 12.7 cm = 0.127 m

45. 1 **46.** 2 **47.** 3
48. 3 **49.** 3

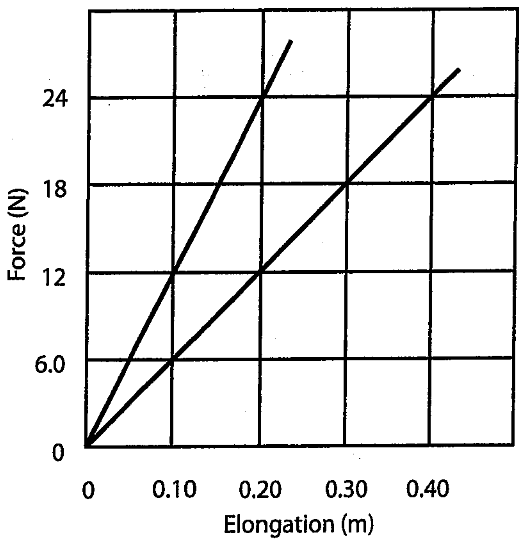
50. $PE_s = \frac{1}{2}kx^2 = \frac{1}{2}(120\ \text{N/m})(0.20\ \text{m})^2 = 0.024\ \text{J}$

51. 2 **52.** 4 **53.** 1
54. 1

55. slope $= k = \frac{\Delta F}{\Delta x} = \frac{24\ \text{N}}{0.40\ \text{m}} = 60.\ \text{N/m}$

56. Example of Acceptable Response

Force vs. Elongation



57. 4 **58.** 3

59. $KE = \frac{1}{2}mv^2$

$v = \sqrt{\frac{2KE}{m}} = \sqrt{\frac{2(96\ \text{J})}{3.0\ \text{kg}}} = 8.0\ \text{m/s}$

60. 1 **61.** 2 **62.** 12 J
63. 1 **64.** 3 **65.** 3
66. 4 **67.** 1 **68.** 2
69. 2

70. $PE_A + KE_A = PE_B + KE_B$

$PE_A = KE_B$

$mgh = KE_B$

$h = \frac{KE_B}{mg} = \frac{1962\ \text{J}}{(20.0\ \text{kg})(9.81\ \text{m/s}^2)} = 10.0\ \text{m}$

71. 3

72. $PE_A + KE_A = PE_B + KE_B$

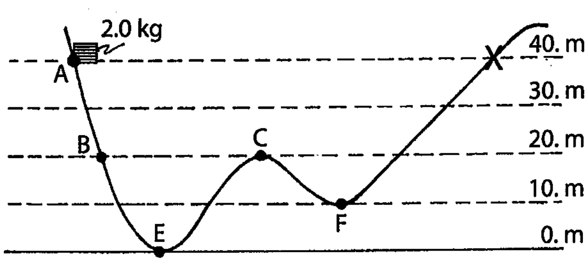
$KE_B = PE_A = mgh = F_g h = (600\ \text{N})(0.5\ \text{m}) = 300\ \text{J}$

73. 3 **74.** 4 **75.** 2
76. 2 **77.** 3 **78.** 3
79. 19.6 J **80.** 2 **81.** 3

82. $\Delta PE = mg\Delta h = (2.0\ \text{kg})(9.81\ \text{m/s}^2)(40.\text{m}) = 780\ \text{J}$

83. 2

84.



85. 4 **86.** 3

87. $KE = \frac{1}{2}mv^2 = \frac{1}{2}(10.0\ \text{kg})(10.0\ \text{m/s})^2 = 500.\ \text{J}$

88. $F = ma = \frac{m\Delta v}{t} = \frac{(10.0\ \text{kg})(10.0\ \text{m/s})}{4.0\ \text{s}} = 25\ \text{N}$

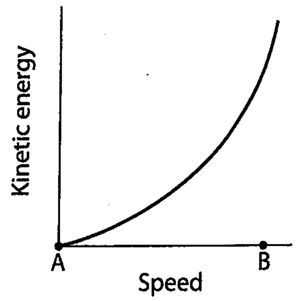
89. $\bar{v} = \frac{d}{t}$

$d = \bar{v}t = (5.00\ \text{m/s})(4.0\ \text{s}) = 20.\ \text{m}$

90. $J = \Delta p = m\Delta v = (10.0\ \text{kg})(-10.0\ \text{m/s}) =$ 100. N · s

91. 2 **92.** 3

93.



94. $PE_A + KE_A = PE_B + KE_B$

$PE_A = KE_B$

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

$h = \frac{v^2}{2g} = \frac{(10.0\ \text{m/s})^2}{2(9.81\ \text{m/s}^2)} = 5.10\ \text{m}$

95. $F_c = \frac{mv^2}{r} = \frac{(1.00\ \text{kg})(10.0\ \text{m/s})^2}{10.0\ \text{m}} = 10.0\ \text{N}$

96. 2 **97.** 2

98. $PE_A + KE_A = PE_B + KE_B + W$

$PE_A = PE_B + F_f d$

$F_f = \frac{PE_A - PE_B}{d} = \frac{mgh_A - mgh_B}{d} = \frac{mg(h_A - h_B)}{d}$

$F_f = \frac{(4.00 \times 10^{-2}\ \text{kg})(9.81\ \text{m/s}^2)(0.80\ \text{m} - 0.50\ \text{m})}{3.60\ \text{m}}$

$= 3.3 \times 10^{-2}\ \text{N}$

99. $W = Fd$ and $F = F_f = \mu F_N = \mu mg$

$W = \mu mgd = (0.67)(1.00 \times 10^3\ \text{kg})(9.81\ \text{m/s}^2)(250\ \text{m}) = 1.6 \times 10^6\ \text{J}$

100. 491 J **101.** 109 J **102.** 1
103. 3 **104.** 1

Regents Practice Questions

1. 3 **2.** 2 **3.** 3
4. 1 **5.** 3 **6.** 2
7. 4 **8.** 1 **9.** 2
10. 2 **11.** 3 **12.** 4
13. 3 **14.** 4 **15.** 4
16. 3 **17.** 3 **18.** 2
19. 4 **20.** 2 **21.** 4
22. 1 **23.** 1 **24.** 2
25. 1 **26.** 2 **27.** 2
28. 3 **29.** 1 **30.** 3
31. 4 **32.** 2 **33.** 4
34. 1 **35.** 1

36. $W = Fd$ and $F_x = F\cos\theta$

$W = (F\cos\theta)(d) = (120\ \text{N})(\cos 37°)(10.\ \text{m}) = 960\ \text{J}$

37. $W = \Delta PE = mg\Delta h = (20.\ \text{N})(3.0\ \text{m}) = 60.\ \text{J}$

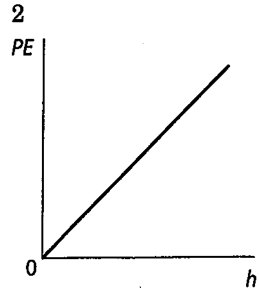
38. $W = Fd$ and $d = vt$

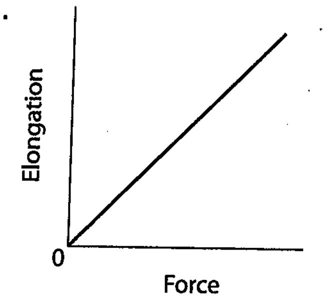
$d = (4.0\ \text{m/s})(6.0\ \text{s}) = 24\ \text{m}$

$W = (20.\ \text{N})(24\ \text{m}) = 480\ \text{J}$

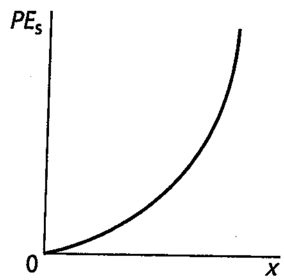
39. 2

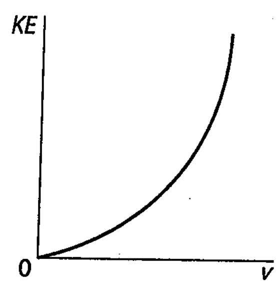
40.



41.


42. the length of the spring before any weight was added

43.


44.


45. $k = \frac{\Delta F}{\Delta x} = \frac{0.50\ \text{N}}{0.20\ \text{m}} = 2.5\ \text{N/m}$

46. $PE_s = \frac{1}{2}kx^2 = \frac{1}{2}(2.5\ \text{N/m})(0.20\ \text{m})^2 = 5.0 \times 10^{-2}\ \text{J}.$

47. 0.050 J

48. 2

49. $\bar{v} = \frac{d}{t}$

$d = \bar{v}t = (1\ \text{m/s})(3\ \text{s}) = 3\ \text{m}$

50. 0.0 N

51. $p = mv = (2.0\ \text{kg})(4\ \text{m/s}) = 8\ \text{kg} \cdot \text{m/s}$

52. $KE = \frac{1}{2}mv^2 = \frac{1}{2}(2.0\ \text{kg})(4.0\ \text{m/s})^2 = 16\ \text{J}$

53. $\overline{BC}$ or $\overline{DE}$

54. 0.0 J

55. $P = \frac{W}{t}$

$W = Pt = (10.0\ \text{W})(2.0\ \text{s}) = 20.\ \text{J}$

56. 6.0 N

57. $a = \frac{F}{m} = \frac{6.0\ \text{N}}{3.0\ \text{kg}} = 2.0\ \text{m/s}^2$

58. $\Delta PE = mg\Delta h = (3.0\ \text{kg})(9.81\ \text{m/s}^2)(4.0\ \text{m}) = 120\ \text{J}$

59. 3

60. $PE_1 + KE_1 = PE_3 + KE_3$

$PE_1 = KE_3 = \frac{1}{2}mv^2 = \frac{1}{2}(2.00\ \text{kg})(6.00\ \text{m/s})^2 = 36.0\ \text{J}$

61. A

62. $a = \frac{v^2}{r} = \frac{(6.00\ \text{m/s})^2}{10.0\ \text{m}} = 3.6\ \text{m/s}^2$

63. The sum of the kinetic and potential energies of the bob at position 1 is equal to the sum of the kinetic and potential energies of the bob at position 2.

64. (8.0 cm)(3.0 m/cm) = 24 m

65. $\Delta PE = mg\Delta h = (650\ \text{kg})(9.81\ \text{m/s}^2)(24\ \text{m}) = 1.5 \times 10^5\ \text{J}$

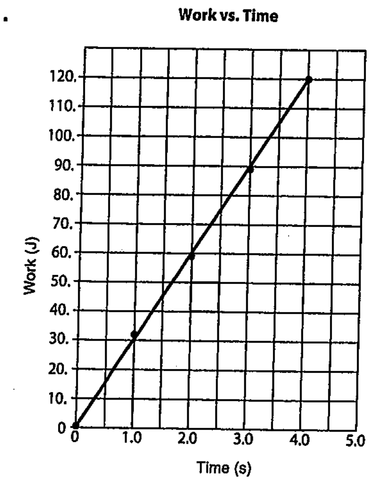
66. The kinetic energy of the car at the top of the second hill is less than the kinetic energy of the car at the top of the third hill.

67. $\Delta PE = mg\Delta h = (6.00\ \text{kg})(9.81\ \text{m/s}^2)(55.0\ \text{m}) = 3240\ \text{J}$

68. $KE = \frac{1}{2}mv^2 = \frac{1}{2}(6.00\ \text{kg})(30.0\ \text{m/s})^2 = 2700\ \text{J}$

69. 540 J

70. The "lost" energy was converted into heat because work was done against friction.

71.


72. slope $= \frac{\Delta W}{\Delta t} = \frac{120.\ \text{J} - 60.\ \text{J}}{4.0\ \text{s} - 2.0\ \text{s}} = 30.\ \text{W}$

73. The slope represents the power developed.

74. 2.5 s

75. The work that must be done to stop a moving object is equal to the kinetic energy of the object. Kinetic energy is given by the formula $KE = \frac{1}{2}mv^2$, so if two objects have the same initial velocity v, the more massive object has the greater kinetic energy. Thus, it requires more work to stop the ferry boat.

76. If no outside work is done on a pendulum, such as giving it a push while swinging, the pendulum cannot possess more energy at any point in its swing than at its point of release. At the instant the bob is released, it has no kinetic energy. All of its energy is potential energy, $PE = mgh$, where h is the height of the bob above the lowest point of its swing. When the bob swings through one cycle and returns to the student, the maximum energy the bob can have is mgh. Thus, the ideal pendulum would return to the tip of the student's nose. In reality, some energy is converted to work done against friction. As a result, the bob rises to some height less than its height at the time of its release.

77. The power developed by the teacher is found by determining the time rate of doing work.

$P = \frac{W}{t} = \frac{Fd}{t} = \frac{(700.\ \text{N})(6.0\ \text{m})}{7.0\ \text{s}} = 600\ \text{W}.$

The teacher develops the same power as the power consumed when six 100-watt light bulbs are turned on.

78. $1.00\ \text{kW}\cdot\text{h} = \frac{1.00\times10^{3}\ \text{J}}{\text{s}}\cdot\text{h}$

$= \frac{1.00\times10^{3}\ \text{J}}{\text{s}}\cdot 1\ \text{h}\left(\frac{60\ \text{min}}{1\ \text{h}}\right)\left(\frac{60\ \text{s}}{1\ \text{min}}\right)$

$= 3.6\times10^{5}\ \text{J}$

79. $PE_{\text{i}} + KE_{\text{i}} = PE_{\text{top}} + KE_{\text{top}}$

$mgh + 0 = mg(2r) + \frac{1}{2}m\nu_{\text{top}}^2$

$gh = g(2r) + \frac{1}{2}\nu_{\text{top}}^2$

And if the car just makes it around the top of the loop, the normal force of the track on the car is zero. Gravity provides the centripetal force.

$F_g = F_c$

$mg = \frac{m\nu^2}{r}$

$\nu^2 = gr$

Substituting,

$gh = g(2r) + \frac{1}{2}gr$

$h = \frac{5r}{2}$

80. During the collision momentum is conserved.

$p_{\text{i}} = p_{\text{f}}$

$m_{\text{B}}\nu_{\text{B}_\text{i}} = (m_{\text{B}} + m_{\text{W}})\nu_{\text{f}}$

$\nu_{\text{f}} = \frac{m_{\text{B}}\nu_{\text{B}_\text{i}}}{m_{\text{B}} + m_{\text{W}}}$

Mechanical energy is conserved after the collision.

$E_{\text{i}} = E_{\text{f}}$

$PE_{\text{BW}_\text{i}} + KE_{\text{BW}_\text{i}} = PE_{\text{BW}_\text{f}} + KE_{\text{BW}_\text{f}}$

$\frac{1}{2}(m_{\text{B}} + m_{\text{W}})\nu_{\text{f}}^2 = (m_{\text{B}} + m_{\text{W}})gh$

$h = \frac{v_{\text{f}}^2}{2g} = \frac{\left(\frac{m_{\text{B}}v_{\text{B}_\text{i}}}{m_{\text{B}} + m_{\text{w}}}\right)^2}{2g}$

81. $T = 2\pi\sqrt{\frac{m}{k}}$

$\left(\frac{T}{2\pi}\right)^2 = \frac{m}{k}$

$k = \frac{m}{\left(\frac{T}{2\pi}\right)^2}$ and

$PE_s = \frac{1}{2}kx^2 = \frac{mx^2}{2\left(\frac{T}{2\pi}\right)^2} = \frac{2\pi^2mx^2}{T^2}$ or $2m\left(\frac{\pi x}{T}\right)^2$

82. $PE_s = KE$

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

$k = \frac{mv^2}{x^2}$ $\quad k = \frac{mv^2}{x^2}$

83. $KE = \frac{1}{2}mv^2$ and $p = mv$

$v = \sqrt{\frac{2KE}{m}}$ and $p = m\sqrt{\frac{2KE}{m}} = \sqrt{2mKE}$

84. $PE = mgh$

85. $PE_{\text{B}} + KE_{\text{B}} = PE_{\text{A}} + KE_{\text{A}}$

$\frac{1}{2}mv_{\text{B}}^2 = mgh$

$v_{\text{B}} = \sqrt{2gh}$

86. $PE_{\text{B}} + KE_{\text{B}} = PE_{\text{C}} + KE_{\text{C}} + PE_{\text{S}}$

$\frac{1}{2}mv_{\text{B}}^2 = mg(-y) + \frac{1}{2}ky^2$

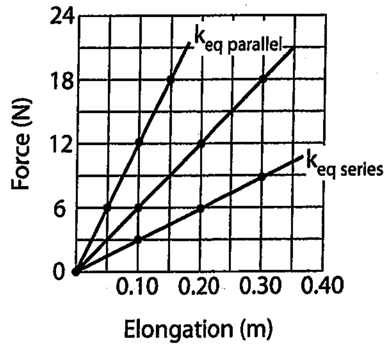
$mv_{\text{B}}^2 = 2mg(-y) + ky^2$

87. $ky^2 = mv_{\text{B}}^2 + 2mgy$

$k = \frac{m}{y^2}(v_{\text{B}}^2 + 2gy)$

88.

Force vs. Elongation



89. See question 88.

90. $PE_{\text{B}} + KE_{\text{B}} = PE_{\text{A}} + KE_{\text{A}}$

$\frac{1}{2}m\nu_{\text{B}}^2 = mg\ell$

$\nu_{\text{B}} = \sqrt{2g\ell}$

91. $PE = mgh = mg(2r) = 2mgr$

92. $PE_{\text{C}} + KE_{\text{C}} = PE_{\text{B}} + KE_{\text{B}}$

$2mgr + \frac{1}{2}m\nu_{\text{C}}^2 = 0 + \frac{1}{2}m\nu_{\text{B}}^2$

but $\frac{1}{2}m\nu_{\text{B}}^2 = mg\ell$

so

$2mgr + \frac{1}{2}m\nu_{\text{C}}^2 = mg\ell$

$\frac{1}{2}m\nu_{\text{C}}^2 = mg\ell - 2mgr$

$\nu_{\text{C}}^2 = 2g\ell - 4gr$

$\nu_{\text{C}} = \sqrt{2g(\ell - 2r)}$

93. 1.2×10^4 N *or* 11,800 N

94. $F_f = \mu F_N$

$F_f = (0.67)(12{,}000\ \text{N})$

$F_f = 8{,}000$ N *or* 8,040 N

95. $W = Fd$

$W = (8{,}000\ \text{N})(16\ \text{m})$

$W = 1.3\times10^5$ J *or* 128,000 J

96. $W = KE = \frac{1}{2}m\nu^2$

$\nu = \sqrt{\frac{2KE}{m}}$

$\nu = \sqrt{\frac{2(1.3\times10^5\ \text{J})}{1.2\times10^3\ \text{kg}}}$

$\nu = 15$ m/s

or

$a = \frac{F_{net}}{m}$

$a = 6.7\ \text{m/s}^2$

$\nu_f^2 = \nu_i^2 + 2ad$

$\nu_i = \sqrt{\nu_f^2 - 2ad}$

$\nu_i = \sqrt{0 - 2(-6.7\ \text{m/s}^2)(16\ \text{m})}$

$\nu_i = 14.6$ m/s

97. $p_{\text{before}} = p_{\text{after}}$

or

$m_{\text{before}}\,v_{\text{before}} = m_{\text{after}}\,v_{\text{after}}$

$(50.\ \text{kg})(6.0\ \text{m/s}) = (60.\ \text{kg})\ v_{\text{after}}$

$v_{\text{after}} = (50.\ \text{kg})\ (6.0\ \text{m/s})/(60.\ \text{kg})$

$v_{\text{after}} = 5.0$ m/s

98. $KE = \frac{1}{2}mv^2$

$KE = \frac{1}{2}(60.\ \text{kg})\ (5.0\ \text{m/s})^2$

$KE = 750$ J

99. 750 J

100. $p_{\text{before}} = p_{\text{after}}$

$m_1\,\nu_{1i} + m_2\,\nu_{2i} = (m_1 + m_2)\nu_f$

$(1000.\ \text{kg})\ (6.0\ \text{m/s}) + (5000.\ \text{kg})\ (0.0\ \text{m/s}) = (1000.\ \text{kg} + 5000.\ \text{kg})\ \nu_f$

$6000\ \text{kg}\cdot\text{m/s} = (6000.\ \text{kg})\ \nu_f$

$\nu_f = 1.0$ m/s

101. $KE = \frac{1}{2}mv^2$

$KE = \frac{1}{2}(6000.\text{ kg})(1.0\text{ m/s})^2$

$KE = 3000\text{ J}$ *or* $3.0 \times 10^3\text{ J}$

102. The *KE* of the combined carts after the collision is less than the *KE* of the carts before the collision.

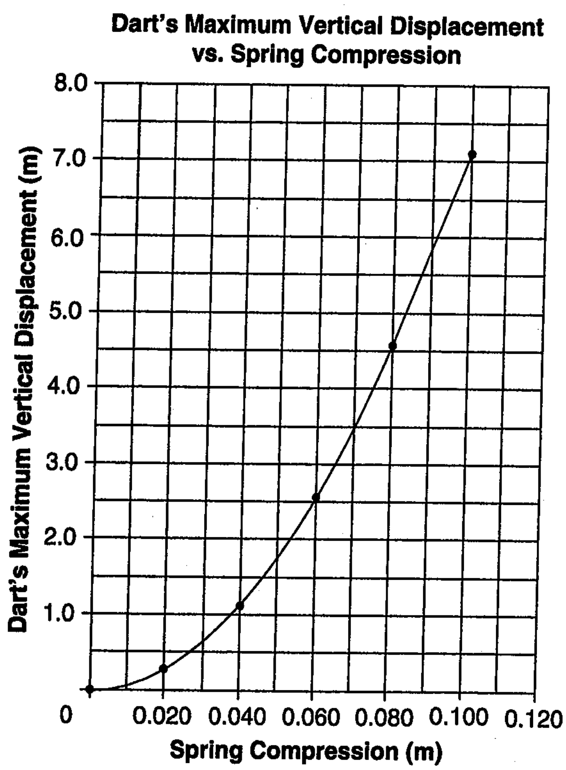
$KE_{before} > KE_{after}$

103. — *B*, because the mass has the greatest speed
— *B*, because the total potential energy is least
— *B*, the speed at *A* and *C* is zero

104. — *A*, because it is the highest point of travel

105. — *C*, because the spring is stretched the maximum amount
— *C*, because the KE and gravitational PE are a minimum

106 and 107.



108. $PE_s = \frac{1}{2}kx^2$

$PE_s = \frac{1}{2}(140\text{ N/m})(0.070\text{ m})^2$

$PE_s = 0.34\text{ J}$

109. 5.6 N

Answers To Topic 4

Review Questions

1. 3 **2.** 2

3. proton +e
electron −e
neutron 0e

4. 1	**5.** 3	**6.** 3
7. 1	**8.** 1	**9.** 3
10. $+2\mu C$	**11.** 2	**12.** 1
13. 4	**14.** 1	**15.** 1

16. 4

17. $F_e = \frac{kq_1q_2}{r^2}$

$= \frac{(8.99 \times 10^9\text{ N}\cdot\text{m}^2/\text{C}^2)(3.0 \times 10^{-7}\text{ C})(4.0 \times 10^{-7}\text{ C})}{(2.0 \times 10^{-2}\text{ m})^2}$

$= 2.7\text{ N}$

18. 4	**19.** 1	**20.** 2
21. 2	**22.** 2	**23.** 3

24. $V = \frac{W}{q} = \frac{6.0\text{ J}}{2.0\text{ C}} = 3.0\text{ V}$

25. 4

26. $V = \frac{W}{q} = \frac{4.0\text{ J}}{2.0\text{ C}} = 2.0\text{ V}$

27. 200. eV

28. potential difference

29. $I = \frac{q}{t} = \frac{20.0\text{ C}}{4.0\text{ s}} = 5.0\text{A}$

30. 3	**31.** 1	**32.** 1
33. 1	**34.** 3	

35. $I = \frac{V}{R}$ and $I = \frac{q}{t}$

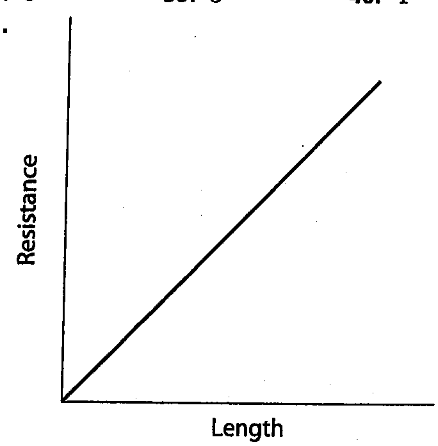
$V = IR = \frac{qR}{t} = \frac{(40.\text{ C})(20.\ \Omega)}{5.0\text{ s}} = 160\text{ V}$

36. 10 Ω

37. $I = \frac{V}{R} = \frac{12\text{V}}{4.0\ \Omega} = 3.0\text{A}$

38. 3	**39.** 3	**40.** 4

41.



42. 4 Ω	**43.** 2	**44.** 1

45. $R = \frac{\rho L}{A}$

$\rho = \frac{RA}{L} = \frac{(0.35\ \Omega)(2.00 \times 10^{-6}\text{ m}^2)}{5.00\text{ m}}$

$= 14 \times 10^{-8}\ \Omega\cdot\text{m}$

46. 4	**47.** 1	**48.** 2
49. 2	**50.** 3	**51.** 2
52. 1	**53.** 70 V	**54.** 1.0 A
55. 2	**56.** 4	**57.** 2
58. 3	**59.** 4	**60.** 4
61. 2	**62.** 3 A	**63.** 33 A
64. 3	**65.** 3	**66.** 4
67. 2	**68.** 3	**69.** 2
70. 4	**71.** 1	**72.** 60. Ω

73. $I = \frac{V}{R} = \frac{120\text{ V}}{60.\ \Omega} = 2.0\text{ A}$

74. $I = I_1 + I_2 = 2.0\text{ A} + 2.0\text{ A} = 4.0\text{ A}$

75. 120 V

76. $\frac{1}{R_{eq}} = \frac{1}{R_1} + \frac{1}{R_2} = \frac{1}{10.\ \Omega} + \frac{1}{15\ \Omega} = \frac{3+2}{30.\ \Omega} = \frac{1}{6.0\ \Omega}$ and

$R_{eq} = 6.0\ \Omega$

77. 12 V

78. $I = \frac{V}{R} = \frac{12\ \text{V}}{10.\ \Omega} = 1.2\ \text{A}$

79. The current in ammeter A_1 is greater than the current in ammeter A_2.

80. If another resistor is added to the circuit in parallel, the equivalent resistance decreases and the total current in the circuit increases.

81. $\frac{1}{R_{eq}} = \frac{1}{R_1} + \frac{1}{R_2}$

$\frac{1}{R_2} = \frac{1}{R_{eq}} - \frac{1}{R_1} = \frac{1}{6.0\ \Omega} - \frac{1}{10.\ \Omega} = \frac{5-3}{30.\ \Omega} = \frac{1}{15\ \Omega}$

$R_2 = 15\ \Omega$

82. $I = \frac{V}{R} = \frac{30.\ \text{V}}{6.0\ \Omega} = 5.0\ \text{A}$

83. $P = \frac{V^2}{R} = \frac{(30.\ \text{V})^2}{10.\ \Omega} = 90.\ \text{W}$

84. The potential difference across the source is equal to the potential difference across R_2, 30. volts.

85. If the resistance of R_2 is increased, the potential difference across it remains 30. volts, but the current through it decreases.

86. 4 87. 4 88. 3
89. 3 90. 2 91. 1
92. 3 93. 3 94. 4

95. $P = \frac{V^2}{R}$

$R = \frac{V^2}{P} = \frac{(120\ \text{V})^2}{4800\ \text{W}} = 3.0\ \Omega$

96. $W = Pt = (4800\ \text{W})(10.0\ \text{s}) = 4.8 \times 10^4\ \text{J}$

97. $P = IV$ and $I = \frac{q}{t}$

$P = \frac{qV}{t}$

$q = \frac{Pt}{V} = \frac{(15\ \text{W})(60.\ \text{s})}{12\ \text{V}} = 75\ \text{C}$

98. 2 99. 2 100. 2
101. 4 102. 1 103. 4

104. at least one is a magnet *or* one is a magnet

105. 3

106. S  N

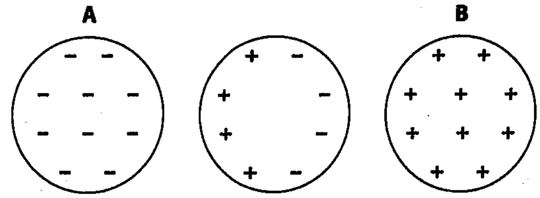
107. 1 108. A 109. C
110. 3 111. 4 112. 1

Regents Practice Questions

Part A

1. 3 2. 3 3. 2
4. 2 5. 4 6. 2
7. 2 8. 4 9. 4
10. 3 11. 3 12. 1
13. 4 14. 1 15. 3
16. 2 17. 3 18. 2
19. 1 20. 2 21. 1
22. 2 23. 3 24. 3
25. 2 26. 3 27. 4
28. 1 29. 2 30. 2
31. 4 32. 3 33. 4
34. 4 35. 2 36. 4
37. 2 38. 1 39. 1
40. 3 41. 4 42. 3
43. 2 44. 2

45.

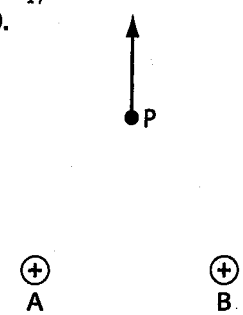


46. $-1.0 \times 10^{-2}\ \text{N}$

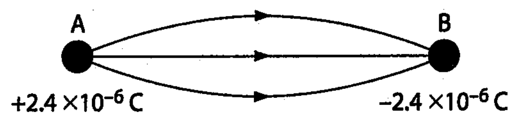
47. $\frac{e}{m} = \frac{1.60 \times 10^{-19}\ \text{C}}{9.11 \times 10^{-31}\ \text{kg}} = 1.76 \times 10^{11}\ \text{C/kg}$

48. $q/4$

49.



50.

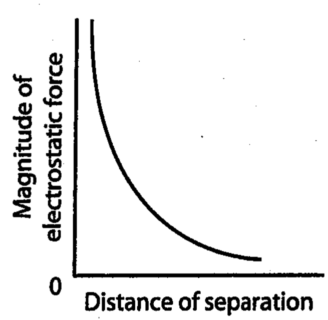


51. $F_e = \frac{kq_1q_2}{r^2}$

$= \frac{(8.99 \times 10^9\ \text{N} \cdot \text{m}^2/\text{C}^2)(2.4 \times 10^{-6}\ \text{C})(2.4 \times 10^{-6}\ \text{C})}{(0.50\ \text{m})^2}$

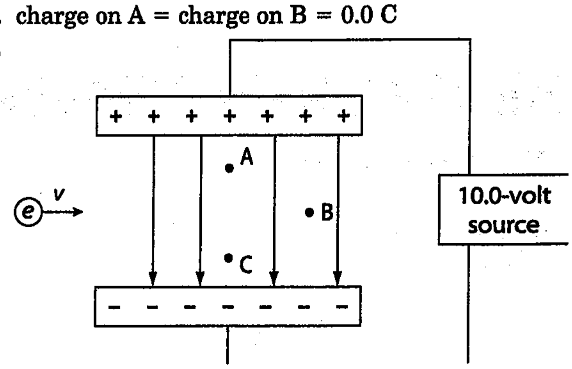
$= 0.21\ \text{N}$

52.



53. charge on A = charge on B = 0.0 C

54.



55. The electron would travel a parabolic path toward the positive plate.

56. The magnitude of the electric field strength at points B and A is the same.

57. $V = \frac{W}{q}$

$W = Vq = (10.0\ \text{V})(-1.60 \times 10^{-19}\ \text{C})$
$= -1.60 \times 10^{-18}\ \text{J}$

58. 1.87×10^6 m/s

59. 3

60. B

61. D

62. A

63. $R = \frac{V}{I} = \frac{1.5\ \text{V}}{2.0\ \text{A}} = 0.75\ \Omega$

64. $P = VI = (1.5\ \text{V})(2.0\ \text{A}) = 3.0\ \text{W}$

65. 120 V

66. $I = \frac{V}{R} = \frac{120\ \text{V}}{20.\ \Omega} = 6.0\ \text{A}$

67. $P = I^2R = (4.0\ \text{A})^2(30.\ \Omega) = 480\ \text{W}$

68. $R = \frac{V}{I}$

$V = IR = (0.50\ \text{A})(5.0\ \Omega) = 2.5\ \text{V}$

69. $W = VIt = (15\ \text{V})(0.50\ \text{A})(10.0\ \text{min})(60\ \text{s/min})$
$= 4.5 \times 10^3\ \text{J}$

70. 10.0 Ω

71. The 5.0-ohm resistor dissipates less power than the 15.0-ohm resistor.

72. Removing the 5.0-ohm resistor from the circuit increases the potential drop across resistor R and increases the current through the ammeter.

73. 8.0 Ω

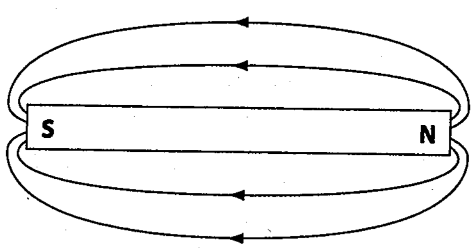
74. $R = \frac{V}{I}$

$I = \frac{V}{R} = \frac{24\ \text{V}}{20.\ \Omega} = 1.2\ \text{A}$

75. 24 Ω

76. 2

77.

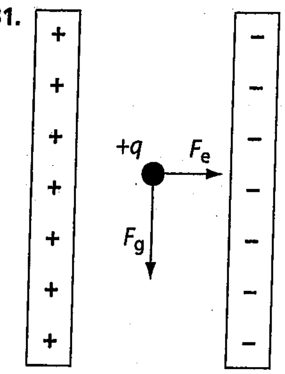


78. A series circuit provides only one current path. Typical electrical devices used in a kitchen include one or more lights, a refrigerator, and a toaster. If these devices were connected in a series circuit, all of the devices would have to be turned on for the refrigerator to operate. If one device was not receiving electricity, none of the other devices would either.

79. Standard incandescent light bulbs are designed to be operated in parallel at 120 volts. The power developed is given by the formula $P = \frac{V^2}{R}$, so power is inversely proportional to resistance. Therefore, the 150-watt bulb has less resistance than the 60-watt bulb. Resistance, $R = \frac{\rho L}{A}$, is directly proportional to length and inversely proportional to cross-sectional area. Thus, a filament of low resistance is relatively thick and short.

80. An electron located between two oppositely charged metal plates experiences an upward electric force that accelerates the electron upward if the upper plate is positively charged and the upward force, exerted by the electric field, is greater than the downward force exerted by the gravitational field.

81.



82. $KE = \frac{1}{2}mv^2$ and $V = \frac{W}{q}$

The maximum speed corresponds to the maximum kinetic energy, which equals the work done on the electron by the field.

$\frac{1}{2}mv^2 = Vq$, but $m = m_e$ and $q = e$

$\frac{1}{2}m_e v^2 = Ve$

$v = \sqrt{\frac{2Ve}{m_e}}$

83. The maximum speed of a proton would be less than that of an electron. Although both particles have the same magnitude of charge e, the proton is more massive than the electron. The maximum speed is inversely proportional to the square root of mass. (See problem 82.)

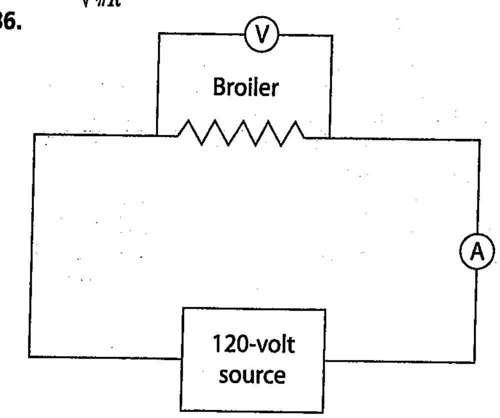
84. $\frac{V}{A} = \frac{\frac{J}{C}}{\frac{C}{s}} = \frac{J \cdot s}{C^2} = \frac{\frac{kg \cdot m^2}{s^2} \cdot s}{C^2} = \frac{\frac{kg \cdot m^2}{s}}{(A \cdot s)^2} = \frac{kg \cdot m^2}{A^2 \cdot s^3}$

85. $R = \frac{\rho L}{A}$ and $A = \pi r^2$

$R = \frac{\rho L}{\pi r^2}$; $r^2 = \frac{\rho L}{\pi R}$

$r = \sqrt{\frac{\rho L}{\pi R}}$

86.



87. $P = \frac{V^2}{R}$

$R = \frac{V^2}{P} = \frac{(120\ \text{V})^2}{1440\ \text{W}} = 10.\ \Omega$

88. $W = Pt = (1440\ \text{W})(10.0\ \text{min})(60.\ \text{s/min})$
$= 8.6 \times 10^5\ \text{J}$

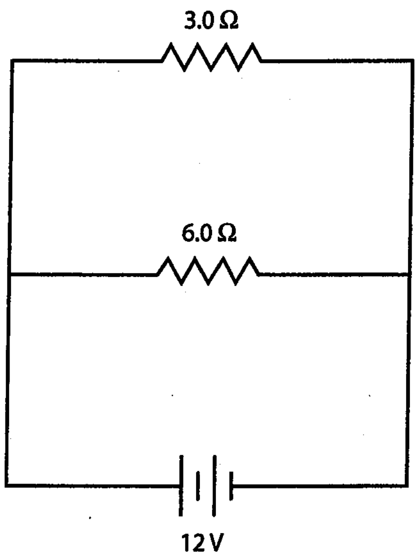
89. $P = VI$

$I = \frac{P}{V} = \frac{1440\ \text{W}}{120\ \text{V}} = 12\ \text{A}$

Because the broiler draws 12 A of current, 3 A additional current can be drawn before the fuse blows.

90. Although the potential drop across the broiler would remain the same, most of the current would go through the short circuit having negligible resistance. Because power is directly proportional to both potential difference and current, the power output of the broiler would decrease.

91.



92. $R = \frac{V}{I}$

$I = \frac{V}{R} = \frac{12\ \text{V}}{6.0\ \Omega} = 2.0\ \text{A}$

93. 12 V

94. $P = \frac{V^2}{R}$ and $\frac{1}{R_{eq}} = \frac{1}{R_1} + \frac{1}{R_2}$

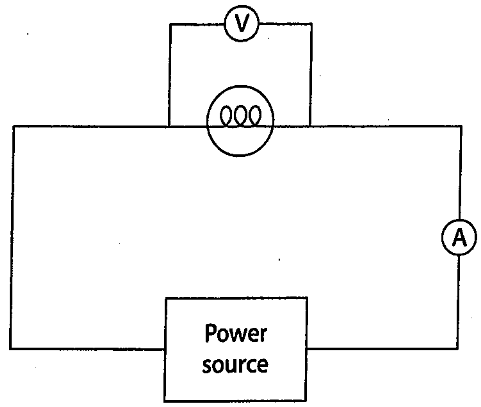
$\frac{1}{R_{eq}} = \frac{1}{3.0\ \Omega} + \frac{1}{6.0\ \Omega} = \frac{2+1}{6.0\ \Omega}$

$P = \frac{(12\ \text{V})^2}{2.0\ \Omega} = 72\ \text{W}$

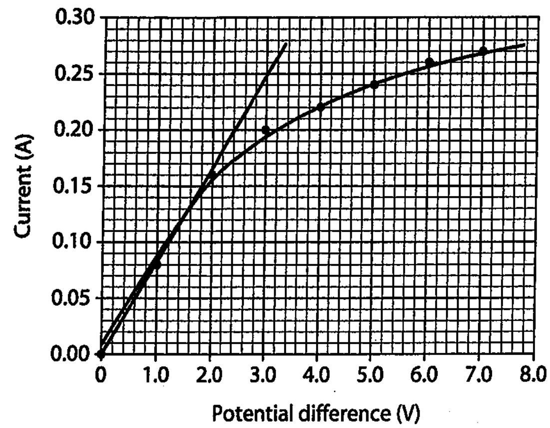
95. Adding an additional 2.0-ohm resistor to the circuit would not change the amount of current drawn by the 6.0-ohm resistor. Only the main line current would increase, as a result of the additional resistor.

96. When connected in parallel, the equivalent resistance is less than the value of either resistor. When connected in series, the equivalent resistance is greater than the value of either resistor.

97.



98. **Current vs. Potential Difference**



99. slope $= \frac{\Delta I}{\Delta V} = \frac{0.21\ \text{A} - 0.18\ \text{A}}{3.4\ \text{V} - 2.6\ \text{V}} = 0.038\ \frac{1}{\Omega}$

100. The slope is the reciprocal of the resistance or $\frac{1}{R}$.

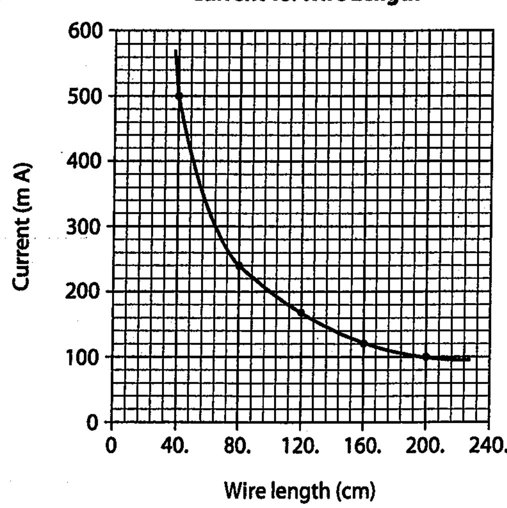
101. The lamp does not obey Ohm's law because the filament gets hot.

102. See answer to question 98.

103. $P = IV = (7.0\ \text{V})(0.27\ \text{A}) = 1.9\ \text{W}$

104. The bulb is not operating at the standard 120 volts.

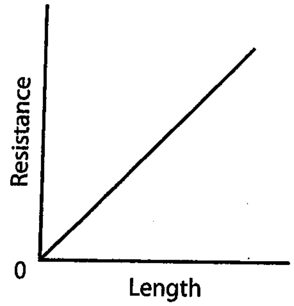
105. **Current vs. Wire Length**



106. The current in the wire is inversely proportional to the wire's length.

107. Ω

108.

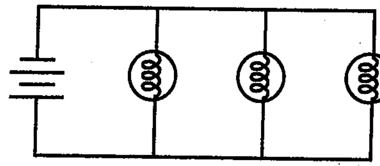


109. $R = \frac{\rho L}{A}$ and $A = \pi r^2$ and $r = d/2$

$\rho = \frac{RA}{L} = \frac{R\pi r^2}{L} = \frac{(20.\ \Omega)\pi(1.59 \times 10^{-4}\ \text{m})^2}{2.00\ \text{m}}$

$= 79 \times 10^{-8}\ \Omega \cdot \text{m}$

110.



111. 40.1 V

112. $\frac{1}{R_{eq}} = \frac{1}{R_1} + \frac{1}{R_2} + \frac{1}{R_3} = \frac{1}{89\ \Omega} + \frac{1}{365\ \Omega} + \frac{1}{143\ \Omega}$

$R_{eq} = 48\ \Omega$ *or* $47.7\ \Omega$

or

$I = I_1 + I_2 + I_3 = 0.45\ \text{A} + 0.11\ \text{A} + 0.28\ \text{A} = 0.84\ \text{A}$

$R = \frac{V}{I} = \frac{40.1\ V}{0.84\ A} = 48\ \Omega$ *or* $47.7\ \Omega$

113. 40.1 V
114. 0.11 A
115. The sphere is attracted to both rods.
116. The sphere is repelled by the positive rod (only).

ANSWERS TO TOPIC 5

Review Questions

1. 4
2. 4
3. 3
4. 3
5. 1
6. 1
7. $T = 0.50$ s
8. 4
9. 3
10. 4
11. frequency
12. 1
13. 1
14. 3
15. 1
16. 2
17. B
18. 2 m
19. 2.0 m
20. $v = f\lambda$ and $f = \frac{1}{T}$

$v = \frac{\lambda}{T} = 8.0\ \text{m}/5.0\ \text{s} = 1.6\ \text{m/s}$

21. 170 m
22. 1
23. A and C
24. A and B *or* C and D
25. A and B *or* C and D
26. 2
27. 2
28. $v = f\lambda$

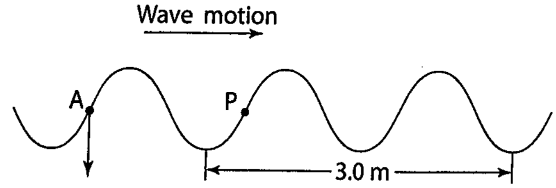
$\lambda = \frac{v}{f} = \frac{331\ \text{m/s}}{250\ \text{Hz}} = 1.3\ \text{m}$

29. $\bar{v} = \frac{d}{t}$

$d = \bar{v}t = (331\ \text{m/s})(3.00\ \text{s}) = 993\ \text{m}$

30. longitudinal

31. and 32.



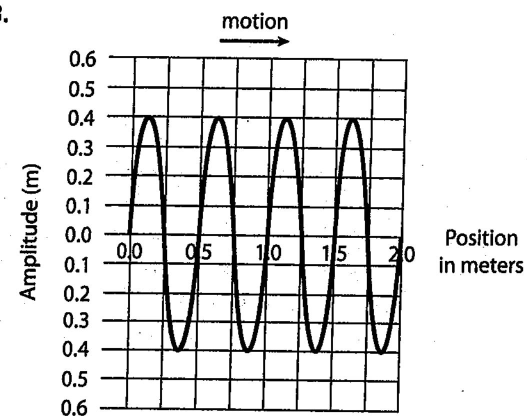
33. $\lambda = \frac{3.0\ \text{m}}{2} = 1.5\ \text{m}$

$v = f\lambda = (40.\ \text{Hz})(1.5\ \text{m}) = 60.\ \text{m/s}$

34. $T = \frac{1}{f} = \frac{1}{40.\ \text{Hz}} = 0.025\ \text{s}$
35. 0.080 s
36. $f = \frac{1}{T} = \frac{1}{0.080\ \text{s}} = 13\ \text{Hz}$
37. $v = \lambda f = (4.0\ \text{m})\left(\frac{1}{2.5\ \text{s}}\right) = 1.6\ \text{m/s}$
38. $\bar{v} = \frac{s}{t}$

$t = \frac{s}{\bar{v}} = \frac{50.\ \text{m}}{1.6\ \text{m/s}} = 31\ \text{s}$

39. 6.4 m
40. $v = \frac{\lambda}{T}$
41. 1
42. 4
43.



44. 150 waves
45. 1
46. 3
47. 1
48. Doppler effect
49. 3
50. 1
51. 2
52. 3
53. 2
54. 1
55. 180°
56. 2
57. A and C
58. 3
59. D
60. 1
61. 3
62. 2
63. 4
64. 4.0 m
65. 3
66. diffraction and interference
67. 2
68. 3
69. 3
70. 4
71. 4
72. 3
73. $v = f\lambda$

$\lambda = \frac{v}{f} = \frac{3.00 \times 10^8\ \text{m/s}}{5.3 \times 10^{14}\ \text{Hz}}$

$= 5.7 \times 10^{-7}\ \text{m}\left(\frac{1\ \text{nm}}{10^{-9}\ \text{m}}\right) = 570\ \text{nm}$

74. 2
75. 1
76. B
77. 2
78. C
79. 2
80. 0°
81. 1
82. 2
83. 2
84. 2
85. 1
86. 3

87. F **88.** 3 **89.** 4

90. $n = \frac{c}{v} = \frac{3.00 \times 10^8 \text{ m/s}}{2.00 \times 10^8 \text{ m/s}} = 1.50$ **91.** 3

92. $\frac{v_1}{v_2} = \frac{n_2}{n_1} = \frac{1.92}{2.42}$

93. diamond

94. 4 **95.** 3 **96.** 1

97. 1 **98.** B **99.** 2

100. 3 **101.** 3 **102.** 3

103. 4 **104.** 4 **105.** 2

106. 3 **107.** green **108.** 10^5 Hz

109. 2 **110.** 3 **111.** 1

112. diamond, crown glass, flint glass, Lucite™, sodium chloride, or zircon

113. $n_1 \sin \theta_1 = n_2 \sin \theta_2$

$$n_2 = \frac{n_1 \sin \theta_1}{\sin \theta_2} = \frac{1.00 \sin 45°}{\sin 30.°} = 1.41$$

114. $n = \frac{c}{v}$

$$v = \frac{c}{n} = \frac{3.00 \times 10^8 \text{ m/s}}{1.5} = 2.0 \times 10^8 \text{ m/s}$$

115. The angle of refraction increases.

116. 45° (±2°)

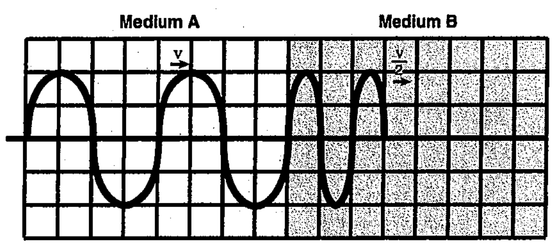
117. 3

118. $n = \frac{c}{v}$

$$v = \frac{c}{n} = \frac{3.00 \times 10^8 \text{ m/s}}{1.4} = 2.1 \times 10^8 \text{ m/s}$$

119. 1 **120.** 3

121.



122. $\bar{v} = \frac{d}{t}$

$$\bar{v} = \frac{2(324 \text{ m})}{0.425 \text{ s}}$$

$$\bar{v} = 1520 \text{ m/s}$$

123. $v = f\lambda$

$$\lambda = \frac{v}{f}$$

$$\lambda = \frac{1520 \text{ m/s}}{1.18 \times 10^3 \text{ Hz}}$$

$$\lambda = 1.29 \text{ m}$$

124. 8.47×10^{-4} s

125. $\frac{n_2}{n_1} = \frac{\lambda_1}{\lambda_2}$

$$\lambda_2 = \frac{n_1 \lambda_1}{n_2}$$

$$\lambda_2 = \frac{(1.00)(5.89 \times 10^{-7} \text{ m})}{2.42}$$

$$\lambda_2 = 2.43 \times 10^{-7} \text{m}$$

126. 0°

127. The frequency of this light in diamond is the same as its frequency in air. The speed of the light in diamond is less than its speed in air.

Regents Practice Questions

1. 2 **2.** 2 **3.** 4

4. 2 **5.** 2 **6.** 1

7. 4 **8.** 1 **9.** 1

10. 3 **11.** 1 **12.** 3

13. 1 **14.** 1 **15.** 3

16. 1 **17.** 3 **18.** 1

19. 3 **20.** 4 **21.** 4

22. 1 **23.** 2 **24.** 3

25. 2 **26.** 1 **27.** 4

28. 4 **29.** 4 **30.** 1

31. 1 **32.** 2 **33.** 4

34. 4 **35.** 1 **36.** 1

37. $\frac{v_1}{v_2} = \frac{\lambda_1}{\lambda_2}$

$$\lambda_2 = \frac{v_2 \lambda_1}{v_1} = \frac{(0.15 \text{ m/s})(0.50 \text{ m})}{0.30 \text{ m/s}} = 0.25 \text{ m}$$

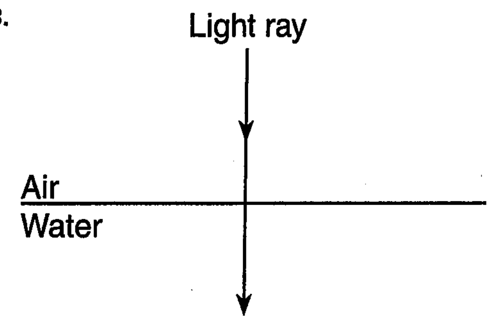
38. 1.41 **39.** 4 **40.** 1

41. 1

42. $v = f\lambda$

$$\lambda = \frac{c}{f} = \frac{3.00 \times 10^8 \text{ m/s}}{1.5 \times 10^{18} \text{ Hz}} = 2.0 \times 10^{-10} \text{m}$$

43.

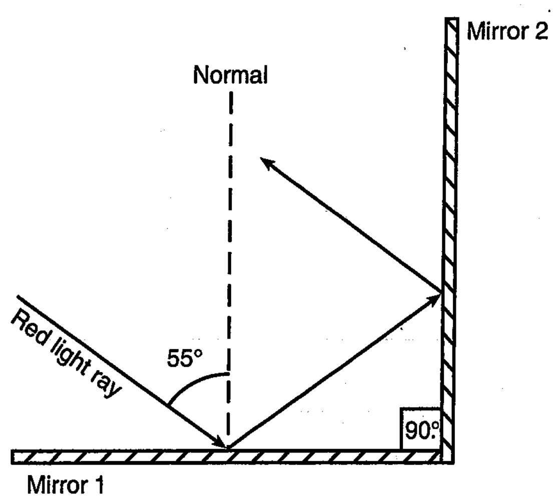


44. $\bar{v} = \frac{s}{t}$

$$t = \frac{s}{\bar{v}} = \frac{1.50 \times 10^{11} \text{ m}}{3.00 \times 10^8 \text{ m/s}} = 5.00 \times 10^2 \text{ s}$$

45. 35° ± 2°

46.



47. 1.95×10^8 m/s

48. B

49. Doppler effect

50. The observed wave frequency at *B* is higher than that at *D*.

51. The wavelength observed at D increases.
52. 0.2 m
53. 2.0 m
54. 1.5 cycles
55. 2.5 Hz
56. $v = f\lambda = (2.5\text{ Hz})(2.0\text{ m}) = 5.0\text{ m/s}$
57. A and G, *or* C and I, *or* D and J
58. down, towards the bottom of the page
59. $n = \frac{c}{v}$

$$v = \frac{c}{n} = \frac{3.00 \times 10^8\text{ m/s}}{1.33} = 2.26 \times 10^8\text{ m/s}$$

60. $n_1 \sin\theta_1 = n_2 \sin\theta_2$

$$\sin\theta_1 = \frac{n_2 \sin\theta_2}{n_1} = \frac{1.00 \sin 45°}{1.33}$$

$$\theta_1 = 32°$$

61. B
62. The speed of light in water is greater than the speed of light in medium X.
63. 1.33
64. $v = f\lambda$ and $n = \frac{c}{v}$

$$\lambda = \frac{v}{f} \quad \text{and} \quad v = \frac{c}{n}$$

$$\lambda = \frac{c}{fn} = \frac{3.00 \times 10^8\text{ m/s}}{(5.09 \times 10^{14}\text{ Hz})(1.33)} = 4.43 \times 10^{-7}\text{ m}$$

65. $v = f\lambda$

$$f = \frac{c}{\lambda} = \frac{3.00 \times 10^8\text{ m/s}}{4.00 \times 10^{-7}\text{ m}} = 7.50 \times 10^{14}\text{ Hz}$$

66. violet
67. $\frac{n_2}{n_1} = \frac{\lambda_1}{\lambda_2}$

$$\lambda_2 = \frac{n_1\lambda_1}{n_2} = \frac{1.00(4.00 \times 10^{-7}\text{ m})}{1.50} = 2.67 \times 10^{-7}\text{ m}$$

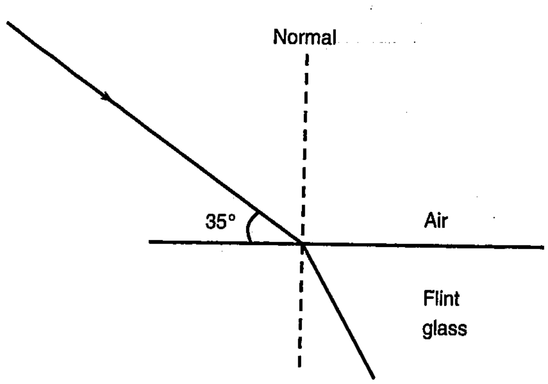
68. The measure of angle A is equal to the measure of angle B.
69. The angle of refraction would increase.
70. 55° (±2°)
71. $n_1 \sin\theta_1 = n_2 \sin\theta_2$

$$\sin\theta_2 = \frac{n_1 \sin\theta_1}{n_2}$$

$$\sin\theta_2 = \frac{(1.00)(\sin 55°)}{1.66}$$

$$\theta_2 = 29.6° \text{ or } 30.°$$

72. 30.° (±2°)
73.



74. $v = f\lambda$

$$\lambda = \frac{v}{f} = \frac{1.5 \times 10^3\text{ m/s}}{5.0 \times 10^3\text{ Hz}} = 0.30\text{ m}$$

75. $\bar{v} = \frac{d}{t}$

$$d = \bar{v}t = (1.5 \times 10^3\text{ m/s})(2.0\text{ s}) = 3.0 \times 10^3\text{ m}$$

76. reflection
77. $\bar{v} = \frac{d}{t}$

$$t = \frac{d}{\bar{v}} = \frac{20.\text{ m}}{340\text{ m/s}} = 0.059\text{ s}$$

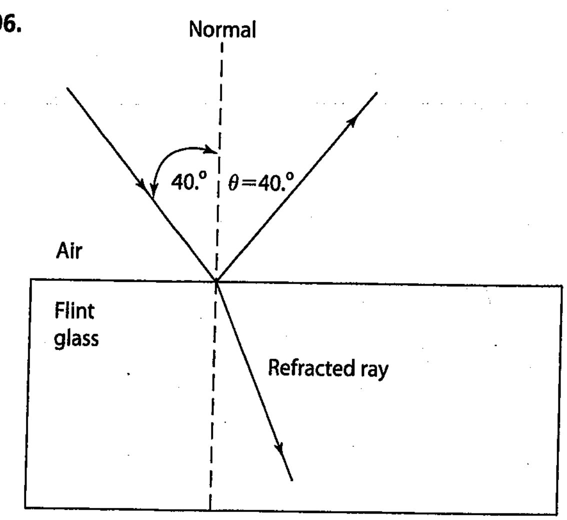
78. $v = f\lambda$

$$\lambda = \frac{v}{f} = \frac{340\text{ m/s}}{10^3\text{ Hz}} = 0.34\text{ m}$$

79. 1λ
80. The frequency of the sound observed at point P increases.
81. 22 m
82. The fire engine produces a sound of constant frequency, or pitch. As the engine approaches you, the distance between successive wave fronts that reach you is decreased. Because the speed of sound is constant, a decrease in wavelength produces an observed increase in frequency or pitch.
83. angle of incidence = 45° (±2°)
angle of refraction = 26° (±2°)
84. The angle of reflection in material X is 64° (±2°).
85. longitudinal
86. resonance
87. range = 0.163 m − 0.149 m = 0.014 m
88. 0.038 m
89. 2
90. $\lambda = 4\ell + 1.6d = 4(0.163\text{ m}) + 1.6(0.032\text{ m})$
$= 0.703\text{ m}$
91. $v = 331\sqrt{1 + \frac{T_C}{273}} = 331\text{ m/s}\sqrt{1 + \frac{21.5}{273}}$
$= 344\text{ m/s}$
92. $\text{Percent Error} = \frac{\text{absolute error}}{\text{accepted value}} \times 100$
$= \frac{6\text{ m/s}}{343\text{ m/s}} \times 100 = 2\%$
93. $3.75 \times 10^{12}\text{ W}$
94. $\text{Heat} = (0.75)(3.75 \times 10^{12}\text{ W})(1.5 \times 10^{-3}\text{ s})$
$= 4.2 \times 10^9\text{ J}$
95. $\bar{v} = \frac{d}{t}$

$$t = \frac{d}{\bar{v}} = \frac{3.0 \times 10^4\text{ m}}{3.31 \times 10^2\text{ m/s}} = 91\text{ s}$$

96.



97. $n_1 \sin \theta_1 = n_2 \sin \theta_2$

$\sin \theta_2 = \frac{n_1 \sin \theta_1}{n_2} = \frac{1.00 \sin 40.°}{1.66}$

$\theta_2 = 23°$

98. See question 96.

99. $n = \frac{c}{v}$, so $v = \frac{c}{n}$ and

$v = f\lambda$, so

$f\lambda = \frac{c}{n}$

$\lambda = \frac{c}{nf} = \frac{3.00 \times 10^8 \text{ m/s}}{1.66(5.09 \times 10^{14} \text{ Hz})} = 3.55 \times 10^{-7} \text{ m}$

100. $n_1 \sin \theta_1 = n_2 \sin \theta_2$

$\sin \theta_2 = \frac{n_1 \sin \theta_1}{n_2}$

$\sin \theta_2 = \frac{1.00 \sin 17°}{1.46}$

$\theta_2 = 12°$ *or* $11.6°$

101. The refracted ray makes an angle of 12°(±2°) with the normal.

102. The angles are measured with a protractor.

$\theta_1 = 45°$ and $\theta_2 = 30.°$

$n_1 \sin \theta_1 = n_2 \sin \theta_2$

$n_2 = \frac{n_1 \sin \theta_1}{\sin \theta_2} = \frac{1.33 \sin 45°}{\sin 30.°} = 1.88$

and $n = \frac{c}{v}$

$v = \frac{c}{n} = \frac{3.00 \times 10^8 \text{ m/s}}{1.88} = 1.60 \times 10^8 \text{ m/s}$

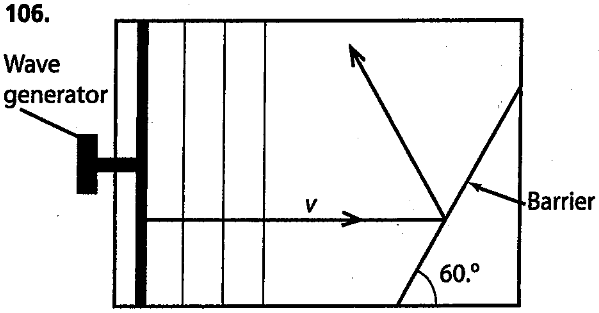
103. $T = \frac{1}{f} = \frac{1}{12 \text{ Hz}} = 0.083 \text{ s}$

104. 0.8 cm *or* 8 mm *or* 0.008 m

105. $v = f\lambda$

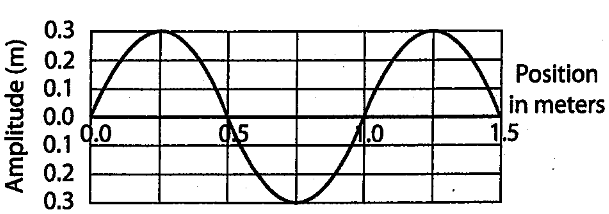
$v = (12 \text{ Hz})(0.8 \text{ cm}) = 10 \text{ cm/s}$

106.



The arrow forms an angle of 60.° ± 2° with the barrier and is directed away from the barrier, as shown.

107.



108. 0.3 m

109. 1.0 m

110. $T = \frac{1}{f}$

$f = \frac{1}{T}$

$f = \frac{1}{5.0 \text{ s}}$

$f = 0.20 \text{ Hz}$

111. $v = f\lambda$ *or* $\bar{v} = \frac{d}{t}$

$v = (0.20 \text{ Hz})(2.0 \text{ m})$ *or* $\bar{v} = \frac{2.0 \text{ m}}{5.0 \text{ s}}$

$v = 0.40 \text{ m/s}$; $\bar{v} = 0.40 \text{ m/s}$

Answers To Topic 6

Review Questions

1. 2 **2.** 4 **3.** 3
4. 4 **5.** 1 **6.** 3
7. 4

8. $E = \frac{hc}{\lambda} = \frac{(6.63 \times 10^{-34} \text{ J·s})(3.00 \times 10^8 \text{ m/s})}{4.00 \times 10^{-7} \text{ m}}$

$= 4.97 \times 10^{-19} \text{ J}$

9. 3 **10.** 3 **11.** 3
12. 1 **13.** 1 **14.** 4
15. 3 **16.** 3

17. 1.26×10^{-18} J

18. bright-line spectrum

19. 3 **20.** 4 **21.** 2
22. 1 **23.** 1

24. $n = 4$ to $n = 2$

25. 4.08×10^{-19} J

26. $E = hf$

$f = \frac{E}{h} = \frac{4.08 \times 10^{-19} \text{ J}}{6.63 \times 10^{-34} \text{ J·s}} = 6.15 \times 10^{14} \text{ Hz}$

27. $E = \frac{hc}{\lambda}$

$E = \frac{(6.63 \times 10^{-34} \text{ J·s})(3.00 \times 10^8 \text{ m/s})}{6.58 \times 10^{-7} \text{ m}}$

$E = 3.02 \times 10^{-19} \text{ J}$

28. 1.89 eV

29. This value is consistent with the $n = 3$ to $n = 2$ transition of 1.89 eV.

30. 2.34×10^{-18} J

31. $E = hf$

$f = \frac{E}{h} = \frac{2.34 \times 10^{-18} \text{ J}}{6.63 \times 10^{-34} \text{ J·s}} = 3.53 \times 10^{15} \text{ Hz}$

32. 4 **33.** 2

34. $E = hf$

$f = \frac{E}{h}$

$= \frac{(-1.51 \text{ eV} - (-3.40 \text{ eV}))(1.60 \times 10^{-19} \text{ J/eV})}{6.63 \times 10^{-34} \text{ J·s}}$

$= 4.56 \times 10^{14} \text{ Hz}$

35. 3 **36.** 4 **37.** 1
38. 4 **39.** 1 **40.** 3
41. 2

42. $E = mc^2 = (2.50 \times 10^{-3}\ \text{kg})(3.00 \times 10^8\ \text{m/s})^2$
$= 2.25 \times 10^{14}\ \text{J}$

43. 3

44. $E = mc^2$

$$m = \frac{E}{c^2} = \frac{9.90 \times 10^{-13}\ \text{J}}{(3.00 \times 10^8\ \text{m/s})^2} = 1.10 \times 10^{-29}\ \text{kg}$$

45. 1 46. 1

47. 10^{-3} pm 48. 10^{-9} nm 49. 10^{36}

50. 2

51. The mass of the neutron is greater than the mass of the proton.

52. The charge on the electron antineutrino is zero *or* neutral.

53. 2 54. 3 55. +1e

56. 0e 57. 1 58. 3

59. 1.67×10^{-27} kg

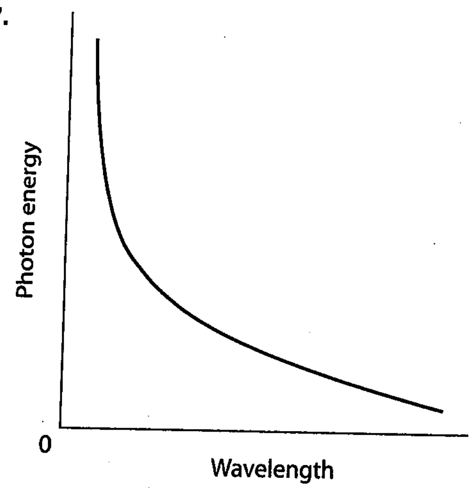
Regents Practice Questions

1. 2 2. 1 3. 3
4. 4 5. 3 6. 1
7. 4 8. 1 9. 3
10. 2 11. 3 12. 2
13. 2 14. 1

15. $\overline{uud}$

16. $E = hf = (6.63 \times 10^{-34}\ \text{J} \cdot \text{s})(5.00 \times 10^{15}\ \text{Hz})$
$= 3.32 \times 10^{-18}\ \text{J}$

17.



18. $v = f\lambda$

$$\lambda = \frac{v}{f} = \frac{3.00 \times 10^8\ \text{m/s}}{1.00 \times 10^{18}\ \text{Hz}} = 3.00 \times 10^{-10}\ \text{m}$$

19. $$\Delta E_{photon} = \frac{hc}{\lambda_f} - \frac{hc}{\lambda_i} = hc\left(\frac{1}{\lambda_f - \lambda_i}\right)$$

The energy gained by the electron equals the energy lost by the photon.

20. $E_{\text{photon}} = E_i - E_f = -5.74\ \text{eV} - (-3.71\ \text{eV})$
$= 2.03\ \text{eV}$

21. 3.25×10^{-19} J

22. $E = hf$

$$f = \frac{E}{h} = \frac{3.25 \times 10^{-19}\ \text{J}}{6.63 \times 10^{-34}\ \text{J} \cdot \text{s}} = 4.90 \times 10^{14}\ \text{Hz}$$

23. Nothing would happen because it is not enough energy to excite the electron to level *b*.

24. 2

25. c^2, the speed of light in a vacuum squared

26. 4

27. $h = 6.63 \times 10^{-34}\ \text{J} \cdot \text{s}$

In fundamental units, $1\ \text{joule} = \frac{1\ \text{kilogram} \cdot \text{meter}^2}{\text{second}^2}$,
so $1\ \text{joule} \cdot \text{second} = \frac{1\ \text{kilogram} \cdot \text{meter}^2}{\text{second}^2} \times \text{second}$
$= \frac{1\ \text{kilogram} \cdot \text{meter}^2}{\text{second}}$

28. $(1.0087\ \text{u})(9.31 \times 10^2\ \text{MeV/u}) = 9.39 \times 10^2\ \text{MeV}$

29. $\Delta m = 3.0170\ \text{u} - [1.0073\ \text{u} + 2(1.0087\ \text{u})]$
$= 0.0077\ \text{u}$

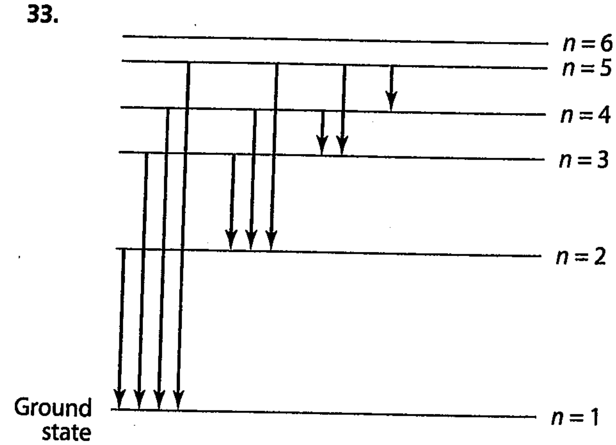
30. __−1__ e → __−1__ e + __0__ e + __0__ e

31. 4

32. $E = mc^2$

$$m = \frac{E}{c^2}$$
$$= \frac{(9.31 \times 10^2\ \text{MeV})(10^6\ \text{eV/MeV})(1.60 \times 10^{-19}\ \text{J/eV})}{(3.00 \times 10^8\ \text{m/s})^2}$$
$= 1.66 \times 10^{-27}$ kg

33.



34. $\lambda = \frac{h}{mv}$

$$\lambda = \frac{6.63 \times 10^{-34}\ \text{J} \cdot \text{s}}{(6.7 \times 10^{-27}\ \text{kg})(2.0 \times 10^6\ \text{m/s})}$$

$\lambda = 4.9 \times 10^{-14}$ m

35. The wavelength of the particle is of the same order of magnitude of gamma rays.

36. $r_n = \frac{n^2h^2}{4\pi^2 m_e k e^2}$

$$= \frac{1^2(6.63 \times 10^{-34}\ \text{J} \cdot \text{s})^2}{4\pi^2(9.11 \times 10^{-31}\ \text{kg})(8.99 \times 10^9\ \text{N} \cdot \text{m}^2/\text{C}^2)(1.60 \times 10^{-19}\ \text{C})^2}$$

$= 5.31 \times 10^{-11}$ m

37. 5.31×10^{-2} nm

38. $$\frac{r_{n=4}}{r_{n=2}} = \frac{\frac{4^2h^2}{4\pi^2 m_e k e^2}}{\frac{2^2h^2}{4\pi^2 m_e k e^2}} = \frac{4^2}{2^2} = \frac{16}{4} = \frac{4}{1}$$

39. $E = mc^2 = 2(9.11 \times 10^{-31}\ \text{kg})(3.00 \times 10^8\ \text{m/s})^2$
$= 1.64 \times 10^{-13}$ J

40. 5.13×10^5 eV

41. $E = hf$

$$f = \frac{E}{h} = \frac{\frac{1}{2}(1.64 \times 10^{-13}\ \text{J})}{6.63 \times 10^{-34}\ \text{J} \cdot \text{s}} = 1.24 \times 10^{20}\ \text{Hz}$$

42. gamma ray *or* X-ray

43. $d = 1.67 \times 10^{-6}$ m

44. $\sin\theta = \frac{50.4 \text{ cm}}{193.9 \text{ cm}} = 0.260$

45. $\lambda = d \sin\theta = (1.67 \times 10^{-6} \text{ m})(0.260)$
$= 4.34 \times 10^{-7} \text{ m}$

46. $4.35833 \times 10^{-7} \text{ m}$

47. $\text{Percent Error} = \frac{\text{absolute error}}{\text{accepted value}} \times 100$
$= \frac{0.02 \times 10^{-7} \text{ m}}{4.358\,33 \times 10^{-7} \text{ m}} \times 100 = 0.5\%$

48. $E = \frac{hc}{\lambda} = \frac{(6.63 \times 10^{-34} \text{ J}\cdot\text{s})(3.00 \times 10^{8} \text{ m/s})}{4.34 \times 10^{-7} \text{ m}}$

$= 4.58 \times 10^{-19} \text{ J}$

49. 2.86 eV

50. f to c

51. 19.34×10^{-19} J
or
1.934×10^{-18} J

52. $E = hf$

$f = \frac{E}{h}$

$f = \frac{19.34 \times 10^{-19} \text{ J}}{6.63 \times 10^{-34} \text{ J}\cdot\text{s}}$

$f = 2.92 \times 10^{15}$ Hz

or

$f = 2.92 \times 10^{15}$ l/s

53. 0.018 63 u

54. 17.3 MeV