WORKED SOLUTIONS TO SELECTED PROBLEMS

Oxford University Press New Century Physics for Queensland, Units 3 & 4

Student Workbook by Deanne O'Callaghan, Paul Fitzgerald and Richard Walding - ISBN 9780190320379

These solutions are copyright 2021, Dr Richard Walding

email: richard@walding.com

CHAPTER 1

Chapter 1 Q6

(b)

$$s_y = u_y t + \tfrac{1}{2} g t^2$$
$$-60 = \tfrac{1}{2}(-9.8)t^2$$
$$t^2 = 12.2$$
$$t = 3.50\,s$$

(c)

$$v_x = \frac{s_x}{t} = \frac{49}{3.5} = 14\,m\,s^{-1} = \frac{14 \times 60 \times 60}{1000} = 50.4\,km\,h^{-1}$$

which is greater than 40 km h^{-1}.

Chapter 1 Q7

(a)

$$s_y = u_y t + \tfrac{1}{2} g t^2$$
$$0 = u_y t + \tfrac{1}{2} g t^2$$
$$u_y t = -\tfrac{1}{2} g t^2$$
$$u_y = -\tfrac{1}{2} g t$$
$$50 \sin 40^\circ = 4.9t$$
$$t = 6.56\,s$$

$$s_x = u_x t = 50 \cos 40^\circ \times 6.56 = 251\,m$$

(b)

$$t_{\text{max ht}} = \frac{6.56}{2} = 3.28\,s$$

$$\begin{aligned} s_y &= u_y t + \tfrac{1}{2} g t^2 \\ &= 50 \sin 40^\circ \times 3.28 + (-4.9) \times 3.28^2 \\ &= 105.4 - 52.7 \\ &= 52.7\,m \end{aligned}$$

Chapter 1 Q8

$$v = 288 \times \frac{1000}{60 \times 60} = 80\,m\,s^{-1}$$

Note: the rest of the question is missing. It should read: How far horizontally from a point directly below where the raft was dropped, will the raft hit the water (assuming no air resistance)?

$$\begin{aligned} s_y &= u_y t + \tfrac{1}{2} g t^2 \\ -250 &= -4.9 t^2 \\ t &= 7.14\,s \\ s_x &= u_x t = 80 \times 7.14 = 570\,m \end{aligned}$$

Chapter 1 Q9

$$\begin{aligned} u_y &= u \sin\theta = 12 \times \sin 32^\circ = 6.36\,m\,s^{-1} \\ s_y &= u_y t + \tfrac{1}{2} g t^2 \\ -2.00 &= 6.36t + (-4.9) \times t^2 \\ 0 &= 4.9t^2 - 6.36t - 2.00 \\ t &= \frac{--6.36 \pm \sqrt{(-6.36)^2 - 4 \times 4.9 \times (-2.00)}}{2 \times 4.9} \\ t &= 1.56\,s\, or - 0.26\,s \text{ [discard negative solution]} \\ s_x &= u_x t = 12 \cos 32^\circ \times 1.56 = 15.9\,m \end{aligned}$$

Chapter 1 Q10

$$s_x = u_x t$$

$$u_x = \frac{s_x}{t} = \frac{7.20}{1.20} = 6.00\,m\,s^{-1}$$

Could also be asked to calculate the angle at which it was thrown:

$$s_y = u_y t + \tfrac{1}{2} g t^2$$
$$1.00 = u_y \times 1.2 + (-4.9) \times 1.2^2$$
$$u_y = 6.71 m s^{-1}$$

$$u_y = u \sin\theta$$
$$u = \frac{u_y}{\sin\theta} = \frac{6.71}{\sin\theta}$$
$$u_x = u \cos\theta$$
$$u = \frac{u_y}{\cos\theta} = \frac{6.00}{\cos\theta} \text{ [equate the } u \text{ equations]}$$
$$\frac{6.00}{\cos\theta} = \frac{6.71}{\sin\theta}$$
$$\frac{\sin\theta}{\cos\theta} = \frac{6.71}{6.00} = 1.12$$
$$\tan\theta = 1.12$$
$$\theta = \tan^{-1} 1.12 = 48.2^\circ$$

CHAPTER 2

Chapter 2 Q1

$$F_{net} = ma$$
$$m = \frac{F_{net}}{a} = \frac{7.25}{16} = 0.453 kg\,(450\, g\, to\, 2\, sf)$$

Chapter 2 Q3

$$F_p = m_1 g \sin\theta = 0.400 \times 9.8 \times 0.5 = 1.96\, N$$
$$F_g = m_2 g = 0.200 \times 9.8 = 1.96\, N$$
$$\vec{F}_{net} = \vec{F_p} + \vec{F_g} = 1.96 + (-1.96) = 0\, N$$

No net force means no acceleration, therefore velocity is constant. As the object was at rest, it will stay at rest (answer C).

Chapter 2 Q6

$F_g = mg = 58 \times 9.8 = 568.4\,N\ down$

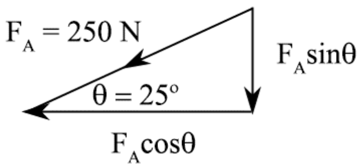
As the gymnast is at rest: $F_T = -F_g$

$F_T = 568.4\ up$

$F_T(each\ rope) = \dfrac{568.4\ up}{2} = 284.2\,N\,up\,(280\,N\,up\,to\,2sf)$

Chapter 2 Q7

(a)



$F_A \cos\theta = 250 \times \cos 25^\circ = 226.6\,N\ (227\,N\,to\,3sf)$

(b)

$$
\begin{aligned}
F_N &= F_g + F_A \sin\theta \\
&= mg + F_A \sin\theta \\
&= 200 \times 9.8 + 250 \times \sin 25^\circ \\
&= 1960 + 105.7 = 2065.6\,N\,up \\
&= 2070\,N\,up\,(to\,3sf)
\end{aligned}
$$

Chapter 2 Q8

(b)

$$
\begin{aligned}
F_f &= F_p \\
F_f &= F_g \sin\theta = mg \sin\theta \\
&= 1.8 \times 10^3 \times 9.8 \times \sin 18^\circ \\
&= 5451\,N\ (5.5 \times 10^3\,N\,to\,2sf)
\end{aligned}
$$

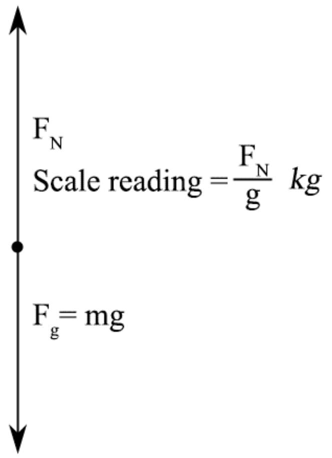
(c)

$$
\begin{aligned}
|F_N| &= F_\perp = mg \cos\theta \\
&= 1.8 \times 10^3 \times 9.8 \times \cos 18^\circ \\
&= 16776.6\,N\ (1.7 \times 10^4\,N\,to\,2sf)
\end{aligned}
$$

Chapter 2 Q9

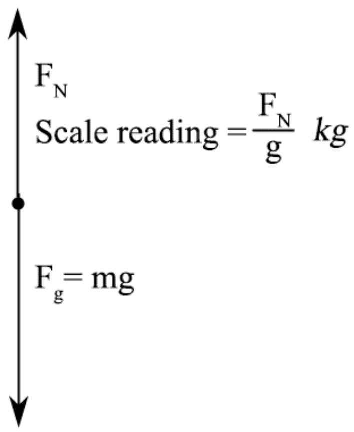
(a)

Let F_N be the normal reaction force generating the scale reading



$$\overrightarrow{F}_{net} = \overrightarrow{F_N} + \overrightarrow{F_g} \; up$$
$$F_{net} = F_N - F_g$$
$$F_N = F_{net} - F_g$$
$$= ma - mg$$
$$= 80 \times (+1.5) - 80 \times (-9.8)$$
$$= 120 + 784$$
$$= 904\,N$$
$$m = \frac{F_N}{g} = \frac{904}{9.8} = 92\,kg$$

(b)



$$\overrightarrow{F}_{net} = \overrightarrow{F_N} + \overrightarrow{F_g} \quad down$$

$$F_{net} = F_N - F_g$$

$$F_N = F_{net} - F_g$$

$$= ma - mg$$

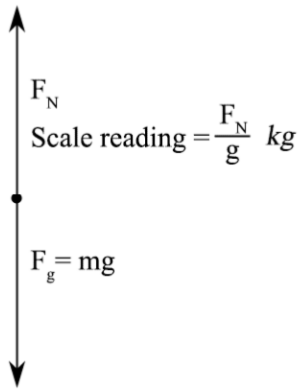
$$= 80 \times (-1.5) - 80 \times (-9.8)$$

$$= -120 + 784$$

$$= +664\, N\, (down)$$

$$m = \frac{F_N}{g} = \frac{664}{9.8} = 68\, kg$$

(c)



$$\overrightarrow{F}_{net} = \overrightarrow{F_N} + \overrightarrow{F_g} \quad = 0\, N \text{ (constant speed)}$$

$$F_{net} = F_N - F_g$$

$$F_N = 0 - F_g$$

$$= 0 - mg$$

$$= 80 \times 9.8$$

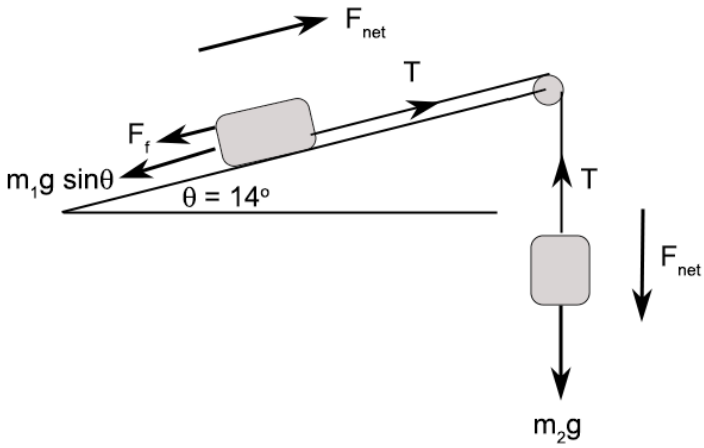
$$= 784\, N$$

$$m = \frac{F_N}{g} = \frac{784}{9.8} = 80\, kg$$

Chapter 2 Q10

(a)

Answer in back is wrong. Correct solution is:



$$
\begin{aligned}
F_{down} &= m_1 g \sin\theta + F_f \\
&= 0.5 \times 9.8 \times \sin 14^\circ + 1.3 \\
&= 1.185 + 1.3 \\
&= 2.485 N \\
F_{up} &= m_2 g \\
&= 0.260 \times 9.8 = 2.548 N \\
F_{net} &= 2.548 - 2.485 = 0.063 N\, up \\
F_{net} &= ma \\
a &= \frac{F_{net}}{m_{total}} = \frac{F_{net}}{m_1 + m_2} = \frac{0.063}{0.760} = 0.083 ms^{-2}
\end{aligned}
$$

(b)

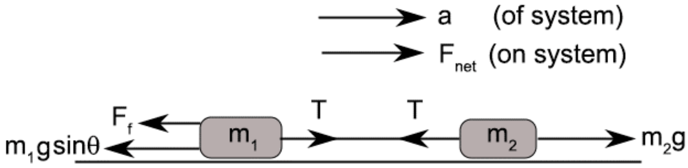
Consider the forces acting on m_1:

$$
\begin{aligned}
F_{net\, m_1} &= T - (m_1 g + F_f) \\
m_1 a &= T - (m_1 g + F_f) \\
T &= m_1 a + (m_1 g + F_f) \\
T &= (0.5 \times 0.083) + 2.485 \\
&= 0.0415 + 2.485 \\
& 2.526 N
\end{aligned}
$$

We could also consider the forces on m_2 to check if our answer for T is correct (has to be the same):

$$
\begin{aligned}
F_{net\, m_2} &= m_2 g - T \\
m_2 a &= m_2 g - T \\
T &= m_2 g - m_2 a \\
&= 2.485 - (0.260 \times 0.083) \\
&= 2.485 - 0.02158 \\
&= 2.526 N
\end{aligned}
$$

Alternatively - the forces can be reduced to a linear representation like this:



$$
\begin{aligned}
F_{net\,m_1} &= T - (m_1 g\sin\theta + F_f) \\
m_1 a &= T - (m_1 g\sin\theta + F_f) \\
T &= m_1 a + (m_1 g\sin\theta + F_f)\ [Eqn1] \\
F_{net\,m_2} &= m_2 g - T \\
m_2 a &= m_2 g - T \\
T &= m_2 g - m_2 a\ [Eqn2] \\
m_1 a + (m_1 g\sin\theta + F_f) &= m_2 g - m_2 a\ \ [equating\ Eqn1\ and\ 2] \\
m_1 a + m_2 a &= m_2 g - (m_1 g\sin\theta + F_f) \\
a(m_1 + m_2) &= m_2 g - m_1 g\sin\theta - F_f \\
a(0.5 + 0.26) &= 0.26\times 9.8 - 0.5\times 9.8\times\sin 14^\circ - 1.3 \\
0.76a &= 2.548 - 1.185 - 1.3 \\
a &= \frac{0.063}{0.76} \\
&= 0.083\,m\,s^{-2}
\end{aligned}
$$

CHAPTER 3

Chapter 3 Q6

(a)

$$F_c = \frac{mv^2}{r} = \frac{1800\times(90000/3600)^2}{80} = 14062\,N$$

$$F_f = 0.65F_g = 0.65mg = 0.65\times 1800\times 9.8 = 11466\,N$$

$$F_f < F_c \ \text{ so will slide}$$

(b)

$$F_c = F_f \quad \text{for no slip}$$

$$F_f = 11466\,N$$

$$F_c = \frac{mv^2}{r} = \frac{1800 \times v^2}{80}$$

$$11466 = \frac{1800 \times v^2}{80}$$

$$v = \sqrt{\frac{11466 \times 80}{1800}} = 22.57\,m\,s^{-1}$$

$$v = 22.57 \times \frac{60 \times 60}{1000} = 81\,km\,h^{-1}$$

Chapter 3 Q7

$$T = \frac{7.09}{10} = 0.709\,s$$

$$v = \frac{2\pi r}{T} = \frac{2\pi \times 0.75}{0.709} = 6.646\,m\,s^{-1}$$

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

$$m_2 g = \frac{m_1 v^2}{r}$$

$$m_2 = \frac{m_1 v^2}{gr} = \frac{0.050 \times (6.646)^2}{9.8 \times 0.75} = 0.300\,kg \;\; (300\,g)$$

Chapter 3 Q8

(a)

$$a_c = \frac{v^2}{r} = \frac{9.0^2}{25} = 3.24\,m\,s^{-2}$$

(b)

$$v = \frac{2\pi r}{T}$$

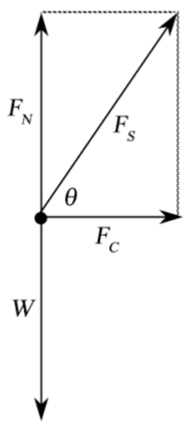
$$T = \frac{2\pi r}{v} = \frac{2\pi \times 25}{9.0} = 17.5\,s$$

Chapter 3 Q9

(a)

$$v=\frac{s}{t}=\frac{\frac{1}{2}\times 2\pi r}{t}=\frac{\frac{1}{2}\times 2\pi \times 10}{3.8}=8.3\,m\,s^{-1}$$

(b) Answer in back is wrong. It is not 900 N but 735 N.



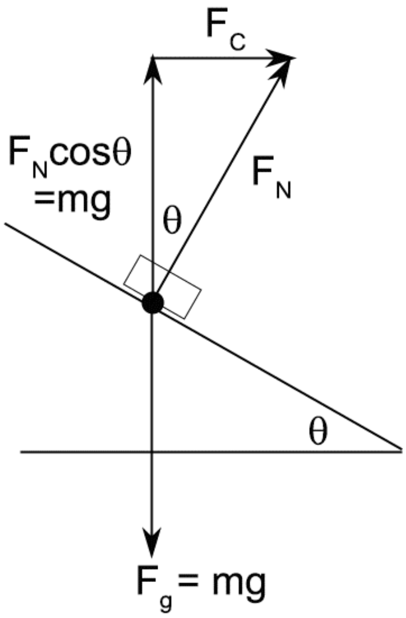
$$\begin{aligned}F_N &= -W = |mg| \\ &= 75\times 9.8 \\ &= 735\,N\end{aligned}$$

(c) Note: Part (c) is not shown in the questions but is in the answers (correctly). It asks you to calculate the angle of F_S with the horizontal.

$$F_C=\frac{mv^2}{r}=\frac{75\times 8.3^2}{10}=513\,N$$

$$\theta=\tan^{-1}\frac{735}{513}=55^\circ$$

Chapter 3 Q10 (b)



There is no motion in the vertical direction thus $F_g = F_N \cos\theta$

$$\tan\theta = \frac{F_c}{mg}$$
$$F_c = mg\tan\theta$$
$$\frac{mv^2}{r} = mg\tan\theta$$
$$\frac{v^2}{gr} = \tan\theta$$
$$\theta = \tan^{-1}\left(\frac{v^2}{gr}\right)$$
$$= \tan^{-1}\left(\frac{(155000/3600)^2}{9.8\times 320}\right)$$
$$= \tan^{-1}0.5911$$
$$= 30.59^\circ$$

CHAPTER 4

Chapter 4 Q1

(B) is correct even though it has different units to the value for G in the formula book (N m^2 kg^{-2})

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

$$G = \frac{F \times r^2}{Mm} = \frac{(ma) \times r^2}{Mm}$$

$$G(units) = \frac{kg\ m s^{-2}\ m^2}{kg^2} = \frac{m^3\ s^{-2}}{kg} = m^3\ s^{-2} kg^{-1}$$

Chapter 4 Q2

$$g = \frac{GM}{r^2}$$

$$\frac{g_E}{g_M} = \frac{\frac{GM_E}{r_E{}^2}}{\frac{GM_M}{r_M{}^2}} = \frac{M_E \times r_M{}^2}{M_M \times r_E{}^2}$$

$$= \frac{18M_M \times r_M{}^2}{M_M \times (2.6r_m)^2}$$

$$= \frac{18}{2.6^2}$$

$$= 2.67$$

Chapter 4 Q3

$$g_{surface} = \frac{GM}{r_E{}^2}$$

$$g_{orbit} = \frac{g_{surface}}{100} = \frac{GM}{100 \times r_E{}^2} = \frac{GM}{(10r_E)^2}$$

Thus, if $r_o = 10r_E$ the g value will be 1/100 of the g on the surface.

Chapter 4 Q4

By the law of conservation of mechanical energy, for an isolated system such as the Earth-ISS system, the total mechanical energy remains constant. Thus, as energy is added from within the system to raise the ISS to a higher orbit, the potential energy (*U*) will increase (actually, it will decrease in negative value, but the effect is the same). This is because work has to be done to increase the separation distance between two objects attracting each other in a gravitational field. This energy comes at the expense of kinetic energy which decreases by an equal amount.

A decrease in E_K means the orbital speed of the ISS also decreases as $E_K = ½ mv^2$. We also know from Kepler's 3rd law that as you increase the orbital distance *r*, the period *T* also increases because T^2/r^3 is a constant. An increase in *T* means a decrease in *v* and hence a decrease in E_K as shown before.

Chapter 4 Q6

(a)

$$R_s = \frac{GM}{c^2} = \frac{6.67\times10^{-11}\times8.58\times10^{36}}{(3\times10^{8})^2}$$
$$= 6.36\times10^{9}\, m$$

(b)

$$g = \frac{GM}{r^2} = \frac{6.67\times10^{-11}\times8.58\times10^{36}}{(6.359\times10^{9})^2}$$
$$= 1.415\times10^{7}\, m\, s^{-2}$$

Chapter 4 Q7

$$T_{SO-2} = 16y$$
$$m_{SO-2} = 2.39\times10^{39}\, kg$$
$$r = 1.79\times10^{13}\, m$$
$$F_g = \frac{Gm_{SagA}m_{SO-2}}{(r_{SO-2})^2} = \frac{6.67\times10^{-11}\times8.58\times10^{36}\times2.39\times10^{39}}{(1.79\times10^{13})^2}$$
$$= 4.27\times10^{39}\, N$$

Note: answer says 4.27 x 10^{31} N but this appears to be wrong.

Chapter 4 Q8

$$m_{rover} = 185\, kg$$
$$m_M = 6.39\times10^{23}\, kg$$
$$r_M = 3.39\times10^{6}\, m$$
$$F_g = \frac{Gm_r m_M}{r_M^2} = \frac{6.67\times10^{-11}\times185\times6.39\times10^{23}}{(3.39\times10^{6})^2}$$
$$= 686\, kg$$

Chapter 4 Q9

$$g = \frac{GM}{r^2}$$

$$\frac{g_M}{g_E} = \frac{\frac{GM_M}{r_M{}^2}}{\frac{GM_E}{r_E{}^2}} = \frac{M_M \times r_E{}^2}{M_E \times r_M{}^2}$$

$$= \frac{7.34\times10^{22}\times(6.37\times10^6)^2}{5.98\times10^{24}\times(1.74\times10^6)^2}$$

$$= 16.45\times10^{-2}$$

$$= 0.1645$$

Chapter 4 Q10

$$F_{ME} = \frac{Gm_M m_E}{r_{M-E}{}^2} = \frac{6.67\times10^{-11}\times7.34\times10^{22}\times5.98\times10^{24}}{(3.80\times10^8)^2}$$

$$= 2.027\times10^{20}\ \textit{to the left}$$

$$F_{MS} = \frac{Gm_M m_S}{r_{M-E}{}^2} = \frac{6.67\times10^{-11}\times7.34\times10^{22}\times5.98\times10^{24}}{(1.49\times10^{11}-3.80\times10^8)^2}$$

$$= 9.743\times10^{20}\ \textit{to the right}$$

$$F_{net} = 9.743\times10^{20}\ \textit{to the right} + 2.027\times10^{20}\ \textit{to the left}$$

$$= 2.3810^{20}\ \textit{to the right}$$

CHAPTER 5

Chapter 5 Q3

$$\frac{T_E^2}{r_E^3} = \frac{T_N^2}{r_N^3}$$

$$\frac{1^2}{1^3} = \frac{164.8^2}{r_N^3}$$

$$r = \sqrt[3]{164.8^2} = 30\,AU$$

Chapter 5 Q4

$$\frac{T^2}{r^3} = \frac{4\pi^2}{GM}$$

$$\frac{(27.4\times 24\times 60\times 60)^2}{(385000\times 10^3)^2} = \frac{4\pi^2}{6.67\times 10^{-11}M}$$

$$M = 6.03\times 10^{24}kg\ [A]$$

Chapter 5 Q7

$$\frac{T^2}{r^3} = \frac{4\pi^2}{GM}$$

$$r^3 = \frac{T^2GM_E}{4\pi^2}$$

$$= \frac{(24\times 60\times 60)^2\times 6.67\times 10^{-11}\times 5.97\times 10^{24}}{4\pi^2}$$

$$= 7.529\times 10^{22}$$

$$r = 4.22\times 10^7 m$$

$$= 4.22\times 10^4 km$$

Chapter 5 Q8

$$\frac{T^2}{r^3} = \frac{4\pi^2}{GM}$$

$$\frac{(93\times 60)^2}{r^3} = \frac{4\pi^2}{GM}$$

$$r^3 = \frac{(93\times 60)^2\times 6.67\times 10^{11}\times 5.97\times 10^{24}}{4\pi^2}$$

$$= 3.14\times 10^{20}$$

$$r = 6.797\times 10^6 m$$

$$= 6.797\times 10^3 km$$

$$altitude = 6.797\times 10^3 km - r_e$$

$$= 6.797\times 10^3 - 6370$$

$$= 427\,km$$

(b)

$$v = \frac{2\pi r}{T} = \frac{2\pi \times 6.797 \times 10^6}{93 \times 60} = 7.65 \times 10^3 ms^{-1}$$

$$= \frac{7.65 \times 10^3 \times 60 \times 60}{1000} = 2.75 \times 10^4 km\, h^{-1}$$

(c)

$$a_c = \frac{v^2}{r} = \frac{(7.65 \times 10^3)^2}{6.797 \times 10^6} = 8.61 m\, s^{-2}$$

Chapter 5 Q9

$$g = \frac{GM}{r^2} = \frac{6.67 \times 10^{-11} \times 6.42 \times 10^{23}}{(3390 \times 10^3)^2}$$

$$= 3.73 m\, s^{-2}$$

Chapter 5 Q10

$$T = 9.87\, d, r = 7.44 \times 10^6\, km, M_{Ross} = ?$$

$$\frac{T^2}{r^3} = \frac{4\pi^2}{GM}$$

$$M = \frac{4\pi^2 r^3}{T^2 G} = \frac{4\pi^2 \times (7.44 \times 10^6 \times 10^3)^3}{(9.87 \times 24 \times 60 \times 60)^2 \times 6.67 \times 10^{11}}$$

$$= 3.35 \times 10^{29} kg$$

CHAPTER 6

Chapter 6 Q1

$$V = \frac{W}{Q}$$

$$W = VQ = (4 \times 1.5) \times 1.5 = 9\, J$$

Chapter 6 Q3

Note: the answer in the back is incorrect. To be (D) a force of 1800 N would require the spheres to be 20 cm apart. Here's the correct answer for a separation of 2.0 cm.

$$F=\frac{kQq}{r^2}=\frac{9\times10^9\times2\times10^{-4}\times4\times10^{-5}}{0.020^2}=180\,000N$$

$$attractive$$

Chapter 6 Q7

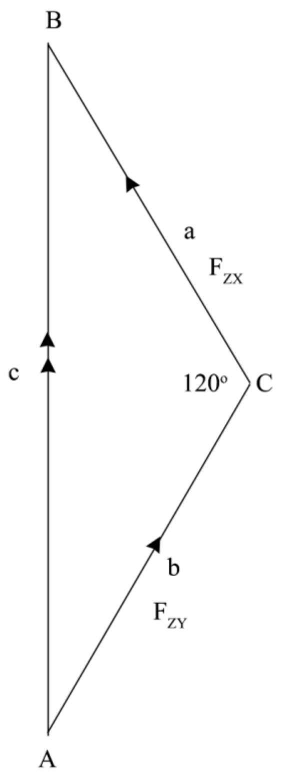
$$F_{ZX}=\frac{kQq}{r^2}=\frac{9\times10^9\times10\times10^{-6}\times8\times10^{-6}}{1.10^2}=0.595N\rightarrow$$

$$F_{ZY}=\frac{kQq}{r^2}=\frac{9\times10^9\times5\times10^{-6}\times8\times10^{-6}}{0.40^2}=2.25N\leftarrow$$

$$F_Z=2.25-0.595=1.655N\leftarrow$$

$$F_Z=2N\ to\ left\ (2sf)$$

Chapter 6 Q8



$$F_{ZX} = \frac{9\times10^9\times2\times10^{-6}\times2\times10^{-6}}{0.08^2} = 5.625N$$

$$F_{ZY} = \frac{9\times10^9\times2\times10^{-6}\times2\times10^{-6}}{0.08^2} = 5.625N$$

$$c^2 = a^2 + b^2 - 2ab\cos C$$

$$= 5.625^2 + 5.625^2 = (2\times5.625\times5.625\times\cos120^\circ)$$

$$= 94.89$$

$$c = 9.74\,N\,up$$

Chapter 6 Q9

(a)

$$E = \frac{F}{q} = \frac{6.0\times10^{-15}}{1.60\times10^{-19}} = 37500\,N\,C^{-1}$$

(b)

$$a = \frac{F_{net}}{m} = \frac{6.0\times10^{-15}}{1.67\times10^{-27}} = 3.6\times10^{12}\,m\,s^{-2}$$

Note: answer in back wrongly says $a = 3.6\times10^{12}\,m\,s^{-23}$

CHAPTER 7

Chapter 7 Q3

Wrong answer in book. For option (D) to be correct it should be 677 turns.

$$B = \mu_0 nI$$

$$0.00567 = 4\pi\times10^{-7}\times\frac{N}{1.5}\times10.0$$

$$N = 677\,turns$$

Chapter 7 Q6

$$B_A = \frac{kI}{r} = \frac{2\times10^{-7}\times3.5}{0.02} = 2.5\times10^{-5}T \ \odot \ out$$

$$B_B = \frac{kI}{r} = \frac{2\times10^{-7}\times2.5}{0.04} = 1.25\times10^{-5}T \ \otimes in$$

$$\begin{aligned} B_{net} &= 2.5\times10^{-5}T \ \odot \ out - 1.25\times10^{-5}T \ \otimes in \\ &= 1.25\times10^{-5}T \ \odot \ out \ of \ page \end{aligned}$$

Chapter 7 Q8

(a)

$$\begin{aligned} F &= BIL\sin\theta = 2\times10^{-3}\times12.0\times0.500\times\sin90^{\circ} \\ &= 0.012\,N\,out\,of\ page \end{aligned}$$

Chapter 7 Q9

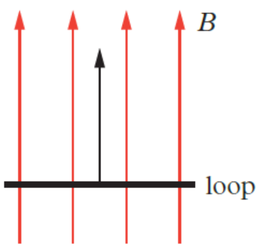
$$\begin{aligned} B &= \mu_0 nI = \mu_0 I \times \frac{N}{L} \\ &= 4\pi\times10^{-7}\times2.0\times\frac{500}{0.200} \\ &= 6.28\times10^{-3}\,T \end{aligned}$$

CHAPTER 8

Chapter 8 Q6

Answer in back is wrong. The flux is not 0.0 Wb

For a loop perpendicular to the field, angle θ = 0° (see below):



$\theta = 0^{\circ}$

$$\phi = BA\cos\theta = 6.0\times 2.0\times\cos 0^{\circ} = 6.0\times 2.0\times 1$$
$$= 12\,Wb$$

Chapter 8 Q8

$$B = \mu_0 nI = 4\pi\times 10^{-7}\times 4000\times 3.0 = 0.0151\,T$$
$$\phi = BA\cos\theta = 0.0151\times(\pi\times 0.03^2)\times\cos 0^{\circ}$$
$$= 4.2\times 10^{-5}\,Wb$$

CHAPTER 9

Chapter 9 Q9

$$t = \frac{t_0}{\sqrt{1-v^2/c^2}} = \frac{8}{\sqrt{1-0.7^2}} = 11.2\,s$$

- to an observer on the ground the time for take-off is 3.2 s longer.

Chapter 9 Q10 To the laboratory observer the particle is moving, so the lab observer measures dilated time *t*.

$$t = \frac{t_0}{\sqrt{1-v^2/c^2}}$$
$$t_0 = 4.2\times 10^{-7}\sqrt{1-0.55^2} = 3.5\times 10^{-7}\,s$$

CHAPTER 10

Chapter 10 Q2

It is moving to you, so you measure contracted length L. Hence you need to find L_0:

$$L = L_0\sqrt{1-v^2/c^2}$$
$$L_0 = \frac{L}{\sqrt{1-v^2/c^2}} = \frac{1.2}{0.8} = 1.5\,m$$

Chapter 10 Q4

$$\begin{aligned}\Delta m &= (1.0078+1.0087)-2.0141\\ &= 0.0042u\\ &= 0.0042u\times 1.66\times 10^{-27}kg/u\\ &= 6.97210^{-30}kg\\ \Delta E &= \Delta mc^2 = 6.97210^{-30}\times(3\times 10^8)^2\\ &= 3.586\times 10^{-13}J\end{aligned}$$

Chapter 10 Q5

$$L = 20ly, v = 0.75c$$

$$v = \frac{L}{t_0}$$

$$t_0 = \frac{L}{v} = \frac{20ly}{0.75c} = \frac{20ly}{0.75ly/y} = 26.7\,y$$

Chapter 10 Q6

(a) Answer in back is wrong

$$L_0 = 117\,m, v = 0.7\,c, L = ?$$

$$\begin{aligned}L &= L_0\sqrt{1-v^2/c^2}\\ &= 117\sqrt{1-0.7^2} = 117\times 0.714 = 83.55\,m\end{aligned}$$

Chapter 10 Q7

The answer in the back of the book is wrong. The speed would be the same. The Earth observer and the space traveller would agree on the relative speed of 0.95c.

However, there appears to be an error in the question. Given the units in the answer (ly) the question probably intended to ask: What distance would the space-traveller measure as the distance from the Earth to the star?

$$L_0 = 45ly, v = 0.95c, L = ?$$
$$L = L_0\sqrt{1-v^2/c^2}$$
$$= 45\sqrt{1-0.95^2} = 45\sqrt{0.3122}$$
$$= 14.05\,ly$$

As a matter of interest, the other values that could be asked are: (a) what would the space-traveller measure as the time for the trip; (b) what time would the Earth observer measure for the same trip?

$$(a)\ t_0 = \frac{L}{v} = \frac{14.05}{0.95} = 14.8\,y$$
$$(b)\ t = \frac{L_0}{v} = \frac{45}{0.95} = 47.4\,y$$

Chapter 10 Q8

Two ways to solve this: the simplest is to calculate the ratio. However, the extended version is to calculate the values of both Newtonian and relativistic momentum, and then express as a ratio, or express as a difference (as the book has done).

Calculating ratios directly:

$$\frac{p_{rel}}{p_N} = \frac{mv}{\dfrac{mv}{\sqrt{1-v^2/c^2}}} = \sqrt{1-v^2/c^2} = 1.67$$
$$Hence: p_{rel} = 1.67\,p_N$$

Calculating momentum of each and expressing as a ratio:

$$p_N = mv = 5\times10^3\times0.8\times3\times10^8 = 1.2\times10^6\,kg\,m\,s^{-1}$$
$$p_{rel} = \frac{mv}{\sqrt{1-v^2/c^2}} = \frac{1.2\times10^6}{\sqrt{1-0.8^2}} = 2.0\times10^6\,kg\,m\,s^{-1}$$
$$\frac{p_{rel}}{p_N} = \frac{2.0\times10^6}{1.2\times10^6} = 1.67$$
$$Hence: p_{rel} = 1.67\,p_N$$

Calculating the algebraic difference (as per answer in book). Note, however, that the answer in the book uses grams for mass rather than the SI unit.

$$p_N = 1.2\times10^6\,kg\,m\,s^{-1}$$
$$p_{rel} = 2.0\times10^6\,kg\,m\,s^{-1}$$
$$\Delta p = 2.0\times10^6 - 1.2\times10^6 = 0.8\times10^6\,kg\,m\,s^{-1}$$
$$\Delta p\% = \frac{\Delta p}{p_N}\times100 = \frac{0.8\times10^6}{1.2\times10^6}\times100 = 67\%$$

That is, relativistic momentum is 67% greater than Newtonian momentum at this speed.

Chapter 10 Q9

There is an error in the solution, but the final answer is correct:

$$\begin{aligned}\Delta m &= 0.158672\,u \\ &= 0.158672u \times 1.66 \times 10^{-27}\,kg/u \\ &= 2.6339 \times 10^{-28}\,kg \\ \Delta E &= \Delta mc^2 = 2.6339 \times 10^{-28} \times (3 \times 10^8)^2 \\ &= 2.37 \times 10^{-11}\,J\end{aligned}$$

CHAPTER 11

Chapter 11 Q2

Error in answer. Option (B) should read $4.44 \times 10^{-19}\,J$

$$\begin{aligned}E_k &= E_{photon} - W \\ &= 9.08 \times 10^{-19} - 4.64 \times 10^{-19} \\ &= 4.44 \times 10^{-19}\,J\end{aligned}$$

Chapter 11 Q7

$$\lambda_{\max} = \frac{b}{T} = \frac{2.898 \times 10^{-3}}{-63 + 273} = 1.38 \times 10^{-5}\,m$$

Chapter 11 Q8

There is an error in the data. The wavelength should be 0.157 µm and UV not green.

$$
\begin{aligned}
E_k &= hf - W \\
&= \frac{hc}{\lambda} - W \\
&= \frac{6.626\times10^{-34}\times3\times10^{8}}{0.157\times10^{-6}} - 5.1\times1.6\times10^{-19} \\
&= 1.266\times10^{-18} - 8.16\times10^{-19}\,J \\
&= 4.55\times10^{-19}\,J \\
&= \frac{4.55\times10^{-19}\,J}{1.6\times10^{-19}\,J/eV} \\
&= 2.84\,eV
\end{aligned}
$$

Actually, it should be 4.5 x 10^{-19} J (2.8 eV)

Chapter 11 Q10

$$\lambda = \frac{h}{p} = \frac{6.626\times10^{-34}}{2.5\times10^{-20}} = 2.65\times10^{-14}\,m$$

$$f = \frac{c}{\lambda} = \frac{3\times10^{8}}{2.65\times10^{-14}} = 1.13\times10^{8}\,Hz$$

CHAPTER 12

Chapter 12 Q1

Note that the table of value in the workbook page 101 are incorrect. The exponent should be 10^{-19} not 10^{-18}. See the Oxford text page 336. Using the values in the SWB gives and answer (B) as stated.

Chapter 12 Q7

The answer in the back is correct. Please note that the diagram should not have the label 'quantum orbitals' as that was not a part of Bohr's original model. It came later.

Chapter 12 Q8

$$L = mvr$$

$$mvr = \frac{nh}{2\pi}$$

$$= \frac{3 \times 6.626 \times 10^{-34}}{2\pi}$$

$$= \frac{1.9878 \times 10^{-33}}{2\pi}$$

$$= 3.165 \times 10^{-34}\, kg\, m^2\, s^{-1}$$

Chapter 12 Q9

There are two approaches to solve this problem. This first uses Rydberg's equation; the second uses energy level data from Table 1 page 101.

RYDBERG'S EQUATION

$$\frac{1}{\lambda} = R_{\mathrm{H}}\left(\frac{1}{n_f^2} - \frac{1}{n_i^2}\right)$$

$$= 1.097 \times 10^7 \left(\frac{1}{5^2} - \frac{1}{2^2}\right)$$

$$\lambda = 4.3408 \times 10^{-7}\, m$$

$$= 434\, nm$$

Values are almost the same (434 nm required but 440 nm available) but not exact. The photon would thus NOT be able to cause the electron to jump from level 2 to level 5.

ENERGY LEVEL DIAGRAM

Note that the table of value in the workbook page 101 are incorrect. The exponent should be 10^{-19} not 10^{-18}. See the Oxford text page 336.

$$E_{2\to5} = E_5 - E_2 = -0.87 \times 10^{-19} - (-5.43 \times 10^{-19})$$

$$= 4.56 \times 10^{-19}\, J$$

$$E = hf = \frac{hc}{\lambda} = \frac{6.626 \times 10^{-34} \times 3 \times 10^8}{440 \times 10^{-9}} = 4.52 \times 10^{-19}\, J$$

Values are almost the same ($4.56 \times 10^{-19}\, J$ required but $4.52 \times 10^{-19}\, J$ available) but not exact. The photon would thus NOT be able to cause the electron to jump from level 2 to level 5.

Chapter 12 Q10

$$\lambda = \frac{h}{p} = \frac{h}{mv} = \frac{6.626\times10^{-34}}{9.11\times10^{-31}\times40000}$$
$$=1.818\times10^{-8}\,m$$

CHAPTER 13

Chapter 13 Q2 There are two correct answers: (A) $\overline{u}\overline{u}\overline{d}$ ($-\frac{2}{3}+\frac{1}{3}+\frac{1}{3}=0$), and (D) udd ($+\frac{2}{3}-\frac{1}{3}-\frac{1}{3}=0$).

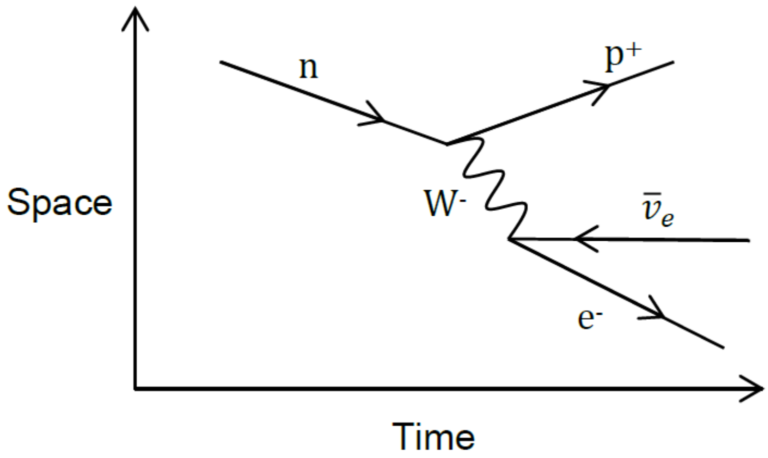
Chapter 13 Q7 Is given as answer to Q9 page 169

Chapter 13 Q8 Is given as answer to Q7 page 169

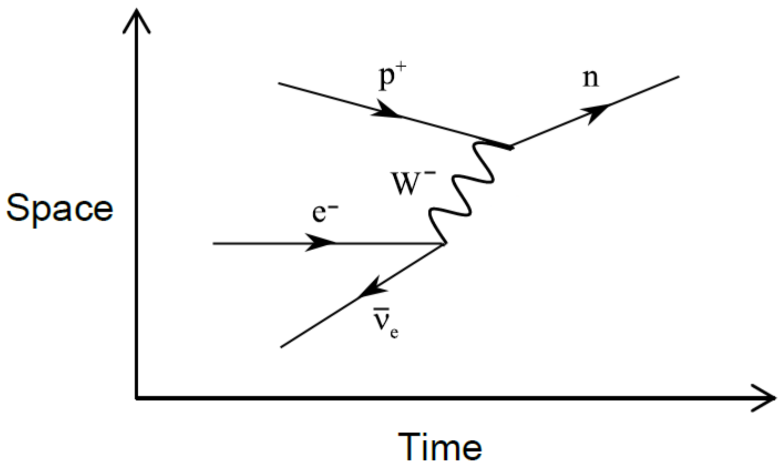
Chapter 13 Q9 Is given as answer to Q8 page 169

Chapter 12 Q10 Answers have been drawn with time on the vertical axis. For time on the horizontal axis as used in the textbook the following would suffice:

(a) Beta negative decay of a neutron



(b) Beta negative decay after a time reversal symmetry operation has been performed.


p+
n
W−
Space
e−
$\bar{\nu}_e$
Time