WORKED SOLUTIONS TO SELECTED PROBLEMS

for OUP NCPQ Unit 1&2 "Student Workbook" ISBN 9780190320362

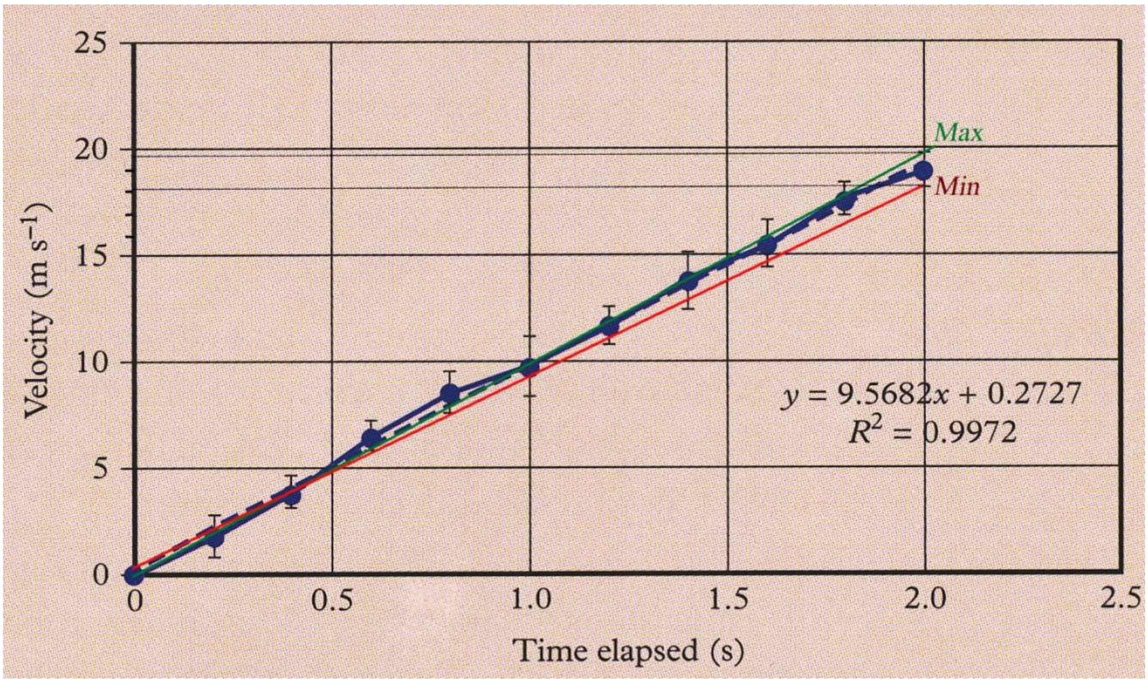
– from Richard Walding 14 July 2021

Note: the answers and most worked solutions are in the back of the Student Workbook p168-185. The solutions included here are those that have no solutions provided. Enjoy!

Chapter 0.2

Data Drill 0.2 b

The maximum and minimum lines of best fit (red and green) are incorrect. They should look like this:



$$\text{max gradient} = \frac{20.0-0}{2.0-0} = 10.0$$

$$\text{min gradient} = \frac{18.0-0}{2.0-0} = 9.0$$

$$\delta x = \frac{\max-\min}{2} = \frac{10.0-9.0}{2} = 0.5$$

$$\delta\% = \frac{\delta x}{x}\times 100 = \frac{0.5}{9.568}$$
$$= 5.2\%$$

$$m = 9.6 \pm 0.5 m\, s^{-1}$$

or

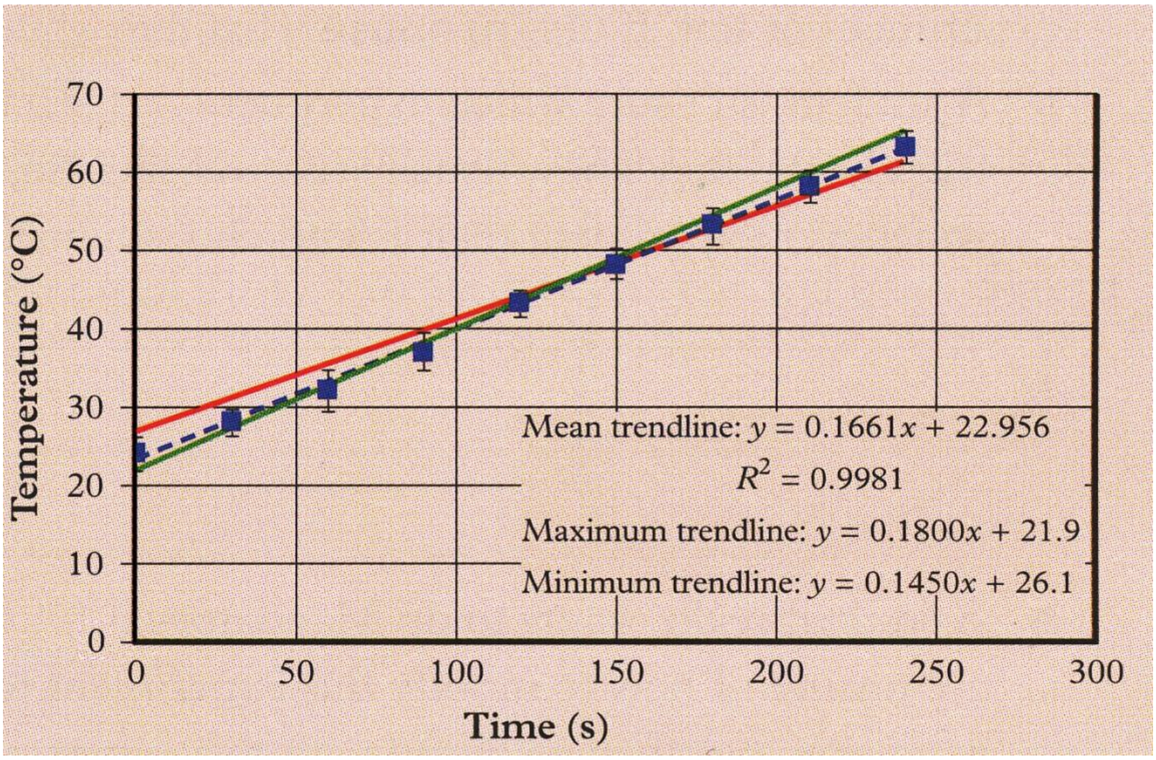
$$m = 9.6 ms^{-1} \pm 5.2\%$$

$$v = (9.6 \pm 0.5)t + 0.3 (to 1 d.p.)$$

Chapter 1 Data Drill

Q1

(a)



Error in the drawing. The graph should not extend back into negative time. It cuts the y-axis at about 25°C at a time of zero seconds.

The relationship is linear but not direct proportion: T = 0.1661t + 22.956 °C

(b)

$$\delta_{gradient} = \pm\frac{\max - \min}{2} = \pm\frac{0.1800 - 0.1450}{2} = \pm 0.0175\,^{\circ}C\,s^{-1}$$

The y-intercept is 22.956 °C (however, the question is really asking for the uncertainty in the y-intercept as well):

$$\delta_{y\text{-intercept}} = \pm\frac{26.19 - 21.9}{2} = \pm 1.6^{\circ}C$$

Chapter 1 Exam Excellence page 13

Q1. Should read “Predict how the *ends of* the bar..”

Q4. Error in answer. Answer is (B)

Q5. Error in answer. Answer is (B)

Q8(a)

$$E_k = \tfrac{3}{2}kT = \tfrac{3}{2}\times 1.38\times 10^{-23}\times(273+35)$$
$$= 6.37\times 10^{-21}\,J$$

Q8(b)

$$E_k = \tfrac{1}{2}mv^2$$
$$v = \sqrt{\frac{2E_k}{m}} = 515\,m\,s^{-1}$$

Chapter 2

Data Drill 2

(a)

$$\bar{x} = \frac{35.4+37.2}{2} = 36.3^{\circ}C$$

(b)

$$\begin{aligned} -Q_{L(metal)} &= Q_{G(water)} \\ -mc\Delta T &= mc\Delta T \\ -\frac{50}{1000}\times c_{metal}\times(36.3-100.0) &= \frac{50}{1000}\times 4180\times(36.3-23.3) \\ 63.7\times c_{metal} &= 4180\times 13 \\ c_{metal} &= 853.06\,J\,kg^{-1}K^{-1} \end{aligned}$$

Exam Excellence 2 page 169

Q4. Answer page 169 is wrong. It is (C)

$$\begin{aligned} -Q_{L(hot\,water)} &= Q_{G(tepid)} \\ -mc\Delta T &= mc\Delta T \\ -0.100\times 4180\times(T_f-90) &= 0.100\times 4180\times(T_f-30) \\ -(T_f-90) &= T_f-30 \\ 2T_f &= 120 \\ T_f &= 60^{\circ}C \end{aligned}$$

Q5. Answer in back of book page 169 is wrong. It is (A)

The liquid range is the sloped line between the 2 x 10^5 and 4 x 10^5 J marks on the x-axis.

$$
\begin{aligned}
Q &= mc\Delta T \\
(4\times10^5 - 2\times10^5) &= 1\times c_{substance}(500-190) \\
2\times10^5 &= c_{substance}\times 310 \\
c_{substance} &= \frac{2\times10^5}{310} \\
&= 645\, J\, kg^{-1}\, K^{-1}
\end{aligned}
$$

Q6

$$
\begin{aligned}
-Q_{L(hot\ water)} &= Q_{G(tepid)} \\
-mc\Delta T &= mc\Delta T \\
-0.100\times c_{brass}\times(T_f-80) &= 0.100\times c_{brass}\times(T_f-24) \\
-(T_f-80) &= T_f-20 \\
2T_f &= 100 \\
T_f &= 50^\circ C
\end{aligned}
$$

Q7. Answer in back of book is wrong. Correct answer is as follows:

$$Q = mL_f$$

$$m = \frac{Q}{L_f} = \frac{7.24\times10^5}{2.76\times10^5} = 2.62\,kg$$

Q10.

$$
\begin{aligned}
-Q_L &= Q_G \\
-(m_W c_W (T_f - T_{i(W)})) &= m_i L_f + m_i c_w (T_f - T_{i(i)}) \\
-(0.200\times4180\times(T_f-35)) &= 0.200\times3.34\times10^5 + 0.200\times4180\times(T_f-0) \\
-836T_f + 2.926\times10^4 &= 6.68\times10^4 + 836T_f \\
-1672T_f &= 6.68\times10^4 - 2.926\times10^4 \\
-1672T_f &= 3.754\times10^4\,[impossible]
\end{aligned}
$$

There is not enough thermal energy in the water to melt all of the ice, so temperature would not rise above 0° C.

We can calculate the mass of ice that would melt:

$$
\begin{aligned}
-Q_L &= Q_G \\
-(m_W c_W (T_f - T_{i(W)})) &= m_i L_f \\
-(0.200 \times 4180 \times (0-35)) &= m_i \times 3.34 \times 10^5 \\
2.926 \times 10^4 &= m_i \times 3.34 \times 10^5 \\
m_i &= \frac{2.926 \times 10^4}{3.34 \times 10^5} \\
m_i &= 0.087\, kg
\end{aligned}
$$

Hence, only 87 g of the 200 g of ice would melt but would stay at 0°C

Chapter 3

Exam Excellence 3

Q2.

System is doing work, in other words, work is being done ***by*** this system, thus W is negative: W = -80 J . Think of this as work coming 'out' of the system: W_{out} = -80 J. If the question said work was done ***on*** the system then it would be W_{in} = +80 J.

Internal energy is increased: thus ΔU is positive: ΔU = +270 J

ΔU = Q + W

+270 = Q + -80

Q = +350 J (Answer (C).

Q4.

$$
\begin{aligned}
\eta &= \frac{E_{out}}{E_{in}} \times 100 = \frac{560}{(180+560)} \times 100 \\
&= 75.6\%
\end{aligned}
$$

Q6

$$
\eta = \frac{E_{out}}{E_{in}} \times 100
$$

$$
35 = \frac{4200}{Q_{in}} \times 100
$$

$$
Q_{in} = 12000\, J
$$

Q7.

We are interested in the energy of the gas (not of the cannister). The gas does work on the cannister, thus, work is done ***by*** the gas so W is negative. Heat energy comes *in* to the gas, so Q is positive.

$$
\begin{aligned}
W &= -100\,kJ \\
Q &= +220\,kJ \\
\Delta U &= Q + W \\
&= +220 + (-100) \\
\Delta U &= +100\,kJ \\
\Delta U &= U_{final} - U_{initial} \\
+100 &= U_{final} - 580 \\
U_{final} &= 680\,kJ
\end{aligned}
$$

Q9 (b)

For a heat engine, there is, by definition, no change in internal energy. That is, ΔU is always zero: ΔU = 0

$$
\begin{aligned}
\Delta U &= Q + W \\
0 &= (Q_{in} - Q_{out}) + W_{out} \\
0 &= (320 - 280) + W_{out} \\
W_{out} &= 40\,kJ \\
\eta &= \frac{W_{out}}{Q_{in}} \times 100 = \frac{40}{320} \times 100 \\
&= 12.5\%
\end{aligned}
$$

Chapter 4

Data Drill 4 page 26

$$
\begin{aligned}
BE_{MeV} &= \Delta m_u \times 931.5\,MeV/u \\
\Delta m_u &= \frac{BE_{MeV}}{931.5\,MeV/u} = \frac{472.359}{931.5} \\
&= 0.5071u
\end{aligned}
$$

$$
\begin{aligned}
\Delta E &= \Delta mc^2 \\
&= 5.044 \times 10^{-21} \times (3 \times 10^8)^2 \\
&= 4.5396 \times 10^{-12}\ J \\
&= \frac{4.5396 \times 10^{-12}\ J}{4\ nucleons} \\
&= 1.135 \times 10^{-12}\ J/nucleon
\end{aligned}
$$

Q8. Answer is back of book page 171 is wrong. The number of nucleons is 23, not 12 and that affects the answer.

Mass of constituent particles is mass of 12 protons + 11 neutrons + 12 electrons:

$$m_{cp} = (12\times1.007276) + (11\times1.008665) + (12\times0.000549)$$
$$= 23.189215u$$
$$\Delta m = m_{cp} - m_{nuclide}$$
$$= 23.189215 - 22.994124 = 0.195091u$$
$$BE = \Delta m \times 931.5 MeV = 181.72 MeV$$
$$BE = \frac{181.72}{23} = 7.90\, MeV / nucleon$$

Exam Excellence 5 page 171

Q6. Should also mention that beta negative decay also produces and electron antineutrino, whereas beta positive decay also produces an electron neutrino.

Data Drill 7 page 41

(a)

$$\delta x = \pm\frac{x_{\max} - x_{\min}}{2} = \pm\frac{4.84 - 4.60}{2} = \pm 0.12V$$
$$\delta\% = \frac{\delta x}{x_o}\times100\% = \frac{0.12}{4.72}\times100\%$$
$$= 2.54\%$$

(b)

$$E_A = |x_O - x_A| = |4.72 - (3\times1.5)| = 0.22V$$
$$E\% = \frac{E_A}{x_A}\times100\%$$
$$= \frac{0.22}{4.5}\times100\%$$
$$= 4.89\%$$

Exam Excellence 7 page 43

Q6.

$$Q = It$$
$$= 12\times3 = 36C$$
$$n = \frac{Q}{q_e} = \frac{36C}{1.6\times10^{-19}C/e}$$
$$= 2.25\times10^{20}\, e$$

Q7.

$$W = Vq = 7.5\times4.2 = 31.5\,J$$

Q8.

$$V = \frac{W}{It} = \frac{1800}{8 \times 75} = 3V$$

Chapter 8

Data Drill 8 page 46

$$\text{max gradient} = 1.8740$$

$$\text{min gradient} = 1.3235$$

$$\delta x = \frac{\text{max} - \text{min}}{2} = \frac{1.8740 - 1.3235}{2} = 0.27345$$

$$\delta\% = \frac{\delta x}{x} \times 100 = \frac{0.27345}{1.5483} \times 100$$

$$= 17.66\%$$

Exam Excellence 8 page 50

Q8.

$$R = \frac{V}{I} = \frac{2.4}{0.3} = 8.0\Omega$$

$$A = \pi r^2 = \pi \left(\frac{0.914 \times 10^{-3}}{2} \right)^2 = 6.561 \times 10^{-7} m^2$$

$$\rho = \frac{RL}{A} = \frac{8.0 \times 1}{6.561 \times 10^{-7}}$$

$$= 5.248 \times 10^{-6} \Omega m^{-1}$$

Q9.

$$P = VI = I^2 R$$

$$R = \frac{P}{I^2} = \frac{60}{(2.5)^2} = 9.6\Omega$$

Q10.

$$\frac{1}{R} = \frac{1}{R_1} + \frac{1}{R_2} + \frac{1}{R_3}$$

$$\frac{1}{R} = \frac{1}{5} + \frac{1}{12} + \frac{1}{18} = 0.339$$

$$R = \frac{1}{0.339} = 2.95\Omega$$

Chapter 9

Data Drill 9 page 52

Q1.

$$\begin{aligned} I_A &= I_{B(av)} + I_{C(av)} \\ &= \frac{3.02+2.99+2.99}{3} + \frac{0.49+0.50+0.47}{3} \\ &= 3.00 + 0.487 \\ &= 3.487\,\Omega \end{aligned}$$

Exam Excellence 9 page 54

Q3.

$$\begin{aligned} W = Pt &= (5\times 25)\times(4\times 60\times 60) \\ &= 1\,800\,000\,J \\ &= 1800\,kJ \end{aligned}$$

Q5.

Note error in question. Refers to data in Q3 on page 54 (not Q4).

$$\begin{aligned} W_{incandescent} &= Pt = (5\times 25)\times(30\times 4\times 60\times 60) \\ &= 5.4\times 10^7\ J \\ W_{LED} &= Pt = (5\times 5.5)\times(30\times 4\times 60\times 60) \\ &= 1.188\times 10^7\ J \\ \Delta W &= W_{incandescent} - W_{LED} \\ &= 5.4\times 10^7 - 1.188\times 10^7 \\ &= 4.212\times 10^7\ J\ (42\,120\,kJ) \end{aligned}$$

Q6.

$$\begin{aligned} R_T &= R_{R1,R2} + R_{R3,R4} + R_5 \\ &= \left(\frac{1}{1/10} + \frac{1}{1/20}\right) + \left(\frac{1}{1/5} + \frac{1}{1/10}\right) + 5 \\ &= 6.67 + 3.33 + 5 \\ &= 15\,\Omega \end{aligned}$$

Q7.

$$I = \frac{V}{R_T} = \frac{15}{15} = 1.0\,A$$

$$V_{R1,R2} = I_{R1,R2} \times R_{R1,R2}$$
$$= 1.0 \times 6.67$$
$$= 6.67V$$

Q9.

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

$$t = \frac{W}{P} = \frac{334.4 \times 10^3}{1.8 \times 10^3}$$
$$= 185.8\,s\,(3\,min\ 6\,s)$$

Unit 1 Practice Assessment

Dataset 2 Item 6

$$Q = mc\Delta T$$
$$1000 \times 150 = 0.500 \times c_w \times (93 - 25)$$
$$c_w \approx 4412\,J\,kg^{-1}K^{-1}$$

Dataset 3 Item 10

UNCERTAINTY IN GRADIENT

Percentage uncertainty in gradient:

$$\text{max gradient} = 35$$
$$\text{min gradient} = 22.5$$

$$\delta x = \frac{\max - \min}{2} = \frac{35 - 22.5}{2} = 6.25\ \Omega m^{-1}$$

$$\delta\% = \frac{\delta x}{x} \times 100 = \frac{6.25}{29.7} \times 100$$
$$= 21.20\%$$

UNCERTAINTY IN AREA

There is an error in the percentage uncertainty calculation. The uncertainty in the area has not been calculated. Thus, the uncertainty due to the scale reading of the digital multimeter should be included. The uncertainty for a digital scale is +/- the smallest increment (0.001 mm).

$$\delta = \pm 0.001 mm$$
$$d = 0.227 \pm 0.001 mm$$
$$= 0.227\, mm \pm \frac{0.001}{0.227} \times 100\%$$
$$= 0.227\, mm \pm 0.44\%$$
$$r = 0.1135 mm \pm 0.44\%$$
$$A = \pi r^2$$
$$= \pi (0.1135 \times 10^{-3})^2 \pm 2 \times 0.44\%$$
$$= 4.047 \times 10^{-8} m^2 \pm 0.88\%$$

UNCERTAINTY IN RESISTIVITY

The percentage uncertainty in the resistivity is the sum of percentage uncertainties in the gradient and the area. This is because the resistivity = gradient x area.

$$\delta\%_{(\rho)} = \pm(21.2 + 0.88) = \pm 22.1\%$$
$$\delta x = \pm 1.20 \times 10^{-6} \Omega m \times \frac{22.1}{100}$$
$$= 2.65 \times 10^{-7}\, \Omega m$$
$$= 0.27 \times 10^{-6} \Omega m$$
$$\rho = 1.20 \times 10^{-6} \Omega m \pm 0.27 \times 10^{-6} \Omega m$$
$$\rho = 1.20 \times 10^{-6} \Omega m \pm 22.1\%$$
$$Range = 0.93 \times 10^{-6} \Omega m\ to 1.47 \times 10^{-6} \Omega m$$

Chapter 10

Data Drill 10 page 178

Q1(b). The answer in the book is wrong. The correct solution is:

$$v_{av} = \frac{14.1 + 13.41 + 13.6}{3} = 13.7 m\, s^{-1}$$
$$\delta x = \frac{\max - \min}{2} = \frac{14.1 - 13.41}{2} = 0.36 m\, s^{-1}$$
$$\delta\% = \frac{\delta x}{x} \times 100 = \frac{0.36}{13.7} \times 100$$
$$= 2.6\%$$

Exam Excellence 10 page 178

Q4. There is no correct option. The answer in the book is wrong. The correct answer 3.6 s.

$$v_{av} = \frac{v+u}{2} = \frac{7+4}{2} = 5.5\,m\,s^{-1}$$

$$v_{av} = \frac{s}{t}$$

$$t = \frac{s}{v_{av}} = \frac{20}{5.5} = 3.64\,s$$

$$OR$$

$$v^2 = u^2 + 2as$$

$$a = \frac{v^2 - u^2}{2s} = \frac{7^2 - 4^2}{2 \times 20} = 0.825\,m\,s^{-2}$$

$$v = u + at$$

$$t = \frac{v-u}{a} = \frac{7-4}{0.825} = 3.64\,s$$

Q8.

Treat A as being at rest and hence the velocity of B is 4.0 m s^{-1} West and 20 m apart.

$$v = \frac{s}{t}$$

$$t = \frac{s}{v} = \frac{20}{4} = 5.0\,s$$

Alternatively:

Let the distance A travels be s_A, and the distance B travels be s_B. We know that $s_a + s_B = 20$ m, hence $s_a = 20 - s_B$.

$$t = \frac{s_A}{v_A} = \frac{s_B}{v_B}$$

$$\frac{s_B - 20}{1.5} = \frac{s_B}{2.5}$$

$$1.5 s_B = 50 - 2.5 s_B$$

$$s_B = 12.5\,m$$

$$t = \frac{s_B}{v_B}$$

$$= \frac{12.5}{2.5} = 5.0\,s$$

Q10.

Determine the area under the curve = 280 m

Chapter 11

Exam Excellence 11 page 76

Q4. The answer is incorrect. The correct answer is (D). The horizontal force of 36N has to be greater than friction and motion is thus in the direction of the horizontal force. If friction acts to the right, motion must be to the left so net force the net force is 36 N – 12 N (= 24 N) to the left.

$$a = \frac{F_{net}}{m} = \frac{24}{8} = 3\,m\,s^{-2}\ to\,the\,left$$

Answer says "(C) 3 m s^{-2} to the right" which is incorrect.

Q5. The answer is incorrect. Option A is wrong as it has the two opposing forces on the right as not applying to anything, and are of unequal lengths as vectors. The most correct option is (B).

Q7.

$$u = 110\,km\,h^{-1} = 30.56\,m\,s^{-1}$$
$$v = 45\,km\,h^{-1} = 12.5\,m\,s^{-1}$$
$$v^2 = u^2 + 2as$$
$$a = \frac{v^2 - u^2}{2s} = \frac{12.5^2 - 30.56^2}{2 \times 54} = -7.2\,m\,s^{-2}$$
$$F_{net} = ma = 1350 \times (-7.2) = -9720\,N$$

Q9. Delete the words "50 cm" from the question as it is wrong.

$$a_1 = \frac{v-u}{t} = \frac{12-4}{5} = 1.6\,m\,s^{-2}$$
$$F_{net} = ma_1 = 2ma_2\ [F_{net}\ \text{is constant}]$$
$$ma_1 = 2ma_2$$
$$a_1 = 2a_2$$
$$1.6 = 2a_2$$
$$a_2 = 0.80\,m\,s^{-2}$$

Note: if the 50 cm is used, a_1 = 128 m s^{-2} or 1.56 m s^{-2} depending on the formula.

Chapter 12

Data Drill 12 page 79

Q1.

$$\begin{aligned}
\Delta p &= p_f - p_i \\
&= (m_A v_A + m_B v_B) - (m_A u_A + m_B u_B) \\
&= (1.600 \times {}^-0.167 + 0.600 \times 2.472) - (1.600 \times 0.863 + 0.600 \times 0) \\
&= (-0.2672 + 1.4832) - (1.3808) \\
&= +1.216 - 1.3808 \\
&= -0.1648\, kg\, m\, s^{-1}
\end{aligned}$$

Exam Excellence 12 page 81

Q5.

$$\begin{aligned}
\Delta p &= m(v-u) \\
Ft &= m(v-u) \\
8000 \times 0.0005 &= 0.046(v-0) \\
v &= 86.96\, m\, s^{-1}\,(B)
\end{aligned}$$

Q6.

$$\begin{aligned}
p_i &= p_f \\
0 &= m_C v_C + m_B v_B \\
&= 900 \times v_C + 5.5 \times 450 \\
v_C &= \frac{2475}{-900} = -2.75\, m\, s^{-1}
\end{aligned}$$

Q7. The question needs correcting. The mass of the ball is 1.0 kg.

$$\begin{aligned}
\Delta p &= p_f - p_i \\
&= mv - mu \\
&= m(v-u) \\
&= m(15 - {}^-15) \\
&= 30m \\
&= 30\, kg\, m\, s^{-1} [\text{assuming a 1kg ball}]
\end{aligned}$$

Q8(b)

$$\begin{aligned}
p_i &= p_f \\
m_A u_A + m_B u_B &= (m_A + m_B) v_{A+B} \\
8.00 \times 15.0 + 5.00 \times 0 &= (8.00 + 5.00) v_{A+B} \\
120 &= 13.00 v_{A+B} \\
v_{A+B} &= \frac{120}{13.00} = 9.23\, m\, s^{-1}\, East
\end{aligned}$$

Q9.

$$
\begin{aligned}
p_i &= m_1u_1 + m_2u_2 \\
&= 1150\times(105\times\frac{1000}{60\times 60}) + 1300\times(-80.0\times\frac{1000}{60\times 60}) \\
&= 3.354\times 10^4 + {}^{-}2.889\times 10^4 \\
&= {}^{+}4.65\times 10^3\, m\, s^{-1}\, East
\end{aligned}
$$

Q10.

$$
\begin{aligned}
p_i &= p_f \\
m_1u_1 + m_2u_2 &= m_1v_1 + m_2v_2 \\
58\times 3 + {}^{-}15\times 5 &= 58\times {}^{-}2 + 15\times v_2 \text{ (work in grams as conversion cancels)} \\
99 &= -116 + 15v_2 \\
215 &= 15v_2 \\
v_2 &= 14.3\, m\, s^{-1}\, East
\end{aligned}
$$

Note: because there is only 1 significant figure in the velocity data, the maximum number of s.f. in the answer should also be 1 s.f. Hence, the answer should be 10 m s^{-1} East. However, it is best to give the answer to 1 d.p. in this case.

Chapter 13

Data Drill 13 page 84

The question has an error in it. It asks for “the instantaneous velocity at the end of the collision”, however, there is no collision, and, at the end of the journey it’s velocity would be zero at the final height reached. The question should say “Predict the instantaneous velocity of the marble at the lowest point of its motion when it was released from a height of 40 cm if the mechanical efficiency was 100%”. Then the answer in the back is correct.

$$
\begin{aligned}
E_p &= E_k \text{ (100\% } mechanical\, efficiency) \\
mgh &= \frac{1}{2}mv^2 \\
gh &= \frac{1}{2}v^2 \\
v &= \sqrt{2gh} = \sqrt{2\times 9.8\times 0.400} \\
&= 2.8\, m\, s^{-1}
\end{aligned}
$$

Exam Excellence 13 page 86

Q5 (D). Answer is correct.

The box is at a constant velocity so the net force is zero. This means the net work done on the box is also zero. To explain this we can say: The pushing force is in the direction of displacement so F and s are both positive. Work is a scalar quantity but is the product of two vectors so when F and s are both positive, the work done on the box is also positive (+W). As it is a rough bench there must be friction acting to oppose the motion. Friction is in the opposite direction to the displacement vector so F is negative while s is positive. Work done on the block by friction is -F x s, so work is negative (-W). The algebraic sum of the work gives the net work done: W_{net} = +W + (-W) = 0.

Q6.

$$
\begin{aligned}
F_{net} &= m_B g = 2\times 9.8 = 19.6N \\
a &= \frac{F_{net}}{m} = \frac{F_{net}}{m_A + m_B} = \frac{19.6}{2+2} = 4.9\,m\,s^{-2} \\
v^2 &= u^2 + 2as \\
&= 0 + 2\times 4.9\times 0.80 = 7.84 \\
v &= 2.8m\,s^{-1} \\
E_{k(B)} &= \frac{1}{2}m_B {v_B}^2 = \frac{1}{2}\times 2\times 7.84 = 7.84\,J \\
&OR \\
W_B &= F_{net(B)}\times s_B \\
&= m_B a_B \times s_B = (2\times 4.9)\times 0.8 \\
&= 7.84J
\end{aligned}
$$

Q7.

$$
\begin{aligned}
W &= \frac{1}{2}mv^2 \\
250 &= \frac{1}{2}\times\frac{50}{1000}v^2 \\
v &= 100\,m\,s^{-1}
\end{aligned}
$$

Q8.

(a)

$$
\begin{aligned}
p_i &= p_f \\
m_A u_A + m_B u_B &= (m_A + m_B)v_{A+B} \\
200\times 85 + 190\times {}^{-}130 &= (200+190)v_{A+B}\ \text{[can leave in km h}^{-1}\text{]} \\
-41700 &= 390 v_{A+B} \\
v_{A+B} &= -106.9\,km\,h^{-1}\,West \\
&= -29.7\,m\,s^{-1}\,West
\end{aligned}
$$

(b) Answer in back is wrong. It is not 0.608 m.

$$F_{net} = ma$$
$$a = \frac{F_{net}}{m} = \frac{1450}{390} = 3.717\, m\, s^{-2}$$
$$v^2 = u^2 + 2as$$
$$0 = 29.7^2 + 2 \times {}^{-}3.717 \times s$$
$$s = 118.6\, m$$

Q9.

(a)

$$p_i = p_f$$
$$m_A u_A + m_B u_B = m_A v_A + m_B v_B$$
$$1.2 \times 4.5 + 1.8 \times 2.5 = 1.2 v_A + 1.8 \times 3.7$$
$$9.9 = 1.2 v_A + 6.66$$
$$1.2 v_A = 3.24$$
$$v_A = 2.7\, m\, s^{-1} \rightarrow (to\, the\, right)$$

(b)

$$E_{k(i)} = \frac{1}{2} m_A u_A{}^2 + \frac{1}{2} m_B u_B{}^2 = 12.15 + 5.625 = 17.775\, J$$
$$E_{k(f)} = \frac{1}{2} m_A v_A{}^2 + \frac{1}{2} m_B v_B{}^2 = 4.374 + 12.321 = 16.695\, J$$

$$E_{\mathrm{k(f)}} \neq E_{\mathrm{k(i)}} \;\; \therefore inelastic$$

Q10

(a)

$$\eta_{electric} = \frac{175}{250} \times 100 = 70\%$$
$$\eta_{fireplace} = \frac{280}{450} \times 100 = 62\%$$

Electric heater is more efficient.

Chapter 14

No additional worked solutions

Chapter 15

Exam excellence 15 page 98

Q1. The question is wrong. None of the options are correct. For an open pipe only odd harmonics are produced, so if the fundamental is 116.5 Hz, the 3rd harmonic will be 3 x 116.5 = 349.5 Hz, and the 5th harmonic will be 582.5 Hz. Suggest the following options are used: (A) 58.2 Hz, (B) 233 Hz, *(C) 350 Hz, (D) 466 Hz.

Chapter 16

Exam excellence 16 page 103

Q1.

$$\begin{aligned} I_1 r_1^{\ 2} &= I_2 r_2^{\ 2} \\ 100 \times 0.5^2 &= 50 \times r_2^{\ 2} \\ r_2^{\ 2} &= \frac{25}{50} \\ r_2 &= 0.71m \end{aligned}$$

Q3.

Wording should be corrected to read: Determine which statement describes what happens when light travels from an *optically* less dense medium into an *optically* denser medium.

Q6.

(a)

$$\frac{P}{A} = I$$

$$\begin{aligned} P = IA &= I \times \pi r^2 \\ &= 350 \times \pi (\frac{10}{2} \times 10^{-2})^2 \\ &= 350 \times (7.85 \times 10^{-3}) \\ &= 2.75W \end{aligned}$$

(b)

Power of light striking lens is 2.75 W as shown in part (a) above. This amount of power is now concentrated to an area of diameter of 1 cm.

$$\begin{aligned} I &= \frac{P}{A} \\ &= \frac{2.75}{\pi (\frac{1}{2} \times 10^{-2})^2} = \frac{2.75}{7.85 \times 10^{-5}} \\ &= 35032 W\,m^{-2} \end{aligned}$$

(c)

The answer in the back of the book is incorrect. It will not catch fire.

The intensity of light in the 1 cm spot is 35032 W m^{-2} as shown in part (b) above. This can be calculated in units of W cm^{-2}:

$$I = \frac{P}{A}$$
$$= \frac{2.75}{\pi(\frac{1}{2})^2} = \frac{2.75}{0.785}$$
$$= 3.50 W\,cm^{-2}$$

This is below the required intensity to light paper of 100 W cm^{-2}, so the paper is unlikely to catch fire.

Unit 2 Data Test page 106

Item 2 (Dataset 1)

$$\delta = \pm\frac{1.846 - 1.834}{2} = 0.0060\,s$$

Item 3 (Dataset 1)

There is a mistake in the question. It should read: "Identify the relationship between the length, L, and the period squared, T^2, of the pendulum." The answer is correct.

Item 4 (Dataset 1)

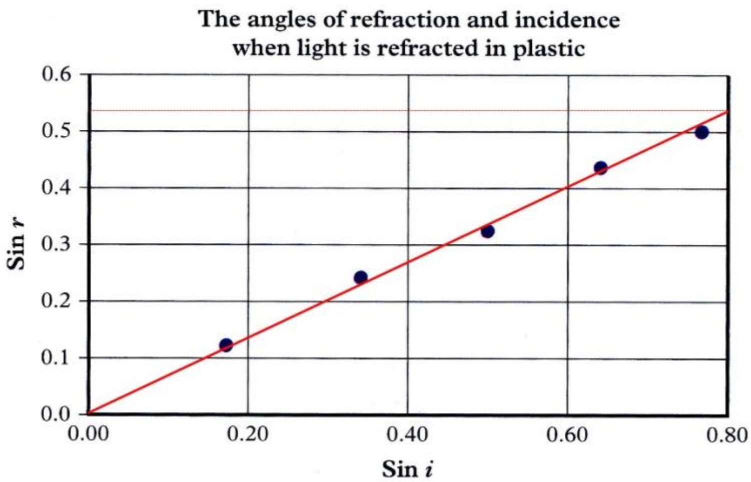
$$L = 1.2 \rightarrow T^2 = 5.2$$
$$T = \sqrt{5.2} = 2.3\,s$$

Item 5 (Dataset 2)

$$gradient = \frac{\sin r}{\sin i}$$
$$n_{air \rightarrow plastic} = \frac{\sin i}{\sin r}$$
$$gradient = \frac{1}{n_{ap}} = n_{pa}$$

Item 6 (Dataset 2)

The gradient depends on how the line of best fit is drawn. For the figure below the y-value when x is 0.80, is 0.54 approximately. Answers between 1.48 to 1.50 would be acceptable.



$$gradient = \frac{0.54-0}{0.80-0} = 0.675$$

$$n_{ap} = \frac{1}{gradient} = \frac{1}{0.675} = 1.48$$

Item 7 (Dataset 2)

The answer in the back is correct for a refractive index of 1.49. For an observed value of 1.48, the error can be calculated:

$$E_A = |x_O - x_A| = |1.49 - 1.51| = 0.02$$

$$E\% = \frac{E_A}{x_A} \times 100 = \frac{0.02}{1.51} \times 100 = 1.3\%$$

This is less than 5% which means the experiment is an accurate means of determining refractive index.

Item 9 (Dataset 3)

$$\delta_{gradient} = \frac{\max - \min}{2} = \frac{11.53 - 7.22}{2} = 2.16\,m\,s^{-2}$$

$$\delta_{y-intercept} = \frac{-0.09 - 1.0}{2} = 0.545\,m\,s^{-1}$$

$$v = (9.17t \pm 2.16) + (0.036 \pm 0.545)\,m\,s^{-1}$$

Item 10 (Dataset 3)

$$a = gradient = 9.17 \pm 2.16\,m\,s^{-2}$$

$$a = 9.17\,m\,s^{-2} \pm \frac{2.16}{9.17} \times 100\% = 9.17\,m\,s^{-2} \pm 23.5\%$$

$$a = 7.01\,m\,s^{-2} \; to \; 11.33\,m\,s^{-2} \; (range)$$

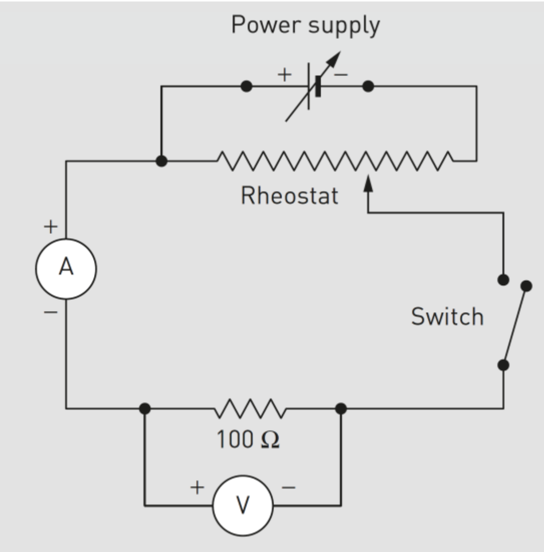
$$E\% = \frac{|x_O - x_A|}{x_A} \times 100 = \frac{9.17 - 9.8}{9.8} \times 100$$

$$= 6.4\%$$

Note: E% is 6.4%. The value in the book of 6.52% on page 185 is incorrect.

Mandatory practical 8.1 page 136.

The diagram in the Student Workbook is incorrect. It is for the non-ohmic resistor (diode). The circuit diagram should be as per the textbook page 480 (below):



Mandatory practical 10.1 page 148.

In Table 2, the heading "Time squared" should have the symbol t^2.

Mandatory practical 16.1 page 165.

Discussion question 1. Line 3. The text should read "(or 1.5/57.1 rad)".