2020 Year 5 Term 3 Timed Practice H2 Physics Solutions

1 **D** Specific heat capacity of water is about 4200 J kg^{-1} K^{-1} and it takes about 5 min for the water in a kettle to boil
$P \times t = m\,C\,\Delta\theta$ (O-level syllabus)
$P \times 300 = 1 \times 4200 \times (100 - 30)$
$P = 980 = 1000$ W

2 **C** Average of results of method P = 9.76 m s^{-2}
Average of results of method Q = 9.56 m s^{-2}
Range of results of method P = 10.12 − 9.51 = 0.61 m s^{-2}
Range of results of method Q = 9.61 − 9.51 = 0.10 m s^{-2}

3 **A** let t be the time taken to travel s

$$s = \frac{1}{2}at_{\text{tot}}^{2}$$

$$0.50s = \frac{1}{2}at^{2} \Rightarrow s = at^{2}$$

$$at^{2} = \frac{1}{2}at_{\text{tot}}^{2}$$

$$t_{\text{tot}} = \left(\sqrt{2}\right)t$$

time taken for remaining $0.5s = \left(\sqrt{2}-1\right)t = 0.41t$

4 **A** gradient of the velocity-time graph is acceleration

5 **B** Assuming that A moves up the slope

$$T - m_A g\sin 30^\circ - f = m_A a \quad \rightarrow [1]$$

$$m_B g - T = m_B a \quad \rightarrow [2]$$

[1] + [2]:

$$m_B g - m_A g\sin 30^\circ - f = \left(m_A + m_B\right)a$$

$$3.0g - 4.0g\left(\frac{1}{2}\right) - f = (7.0)(1.0)$$

$$f = g - 7 = 2.81\text{ N}$$

6 **B**

$$m_1u_1 + m_2u_2 = m_1v_1 + m_2v_2$$

$$(1.0)3.5 + (7.0)1.0 = 1.0\boldsymbol{v} + (7.0)1.6$$

$$\boldsymbol{v} = -0.70\text{ m s}^{-1}$$

7 **C**

$$F = m_T a = 4ma$$

$$F - T_1 = m_x a \quad \Rightarrow T_1 = 4ma - ma = 3ma$$

$$T_2 = m_x a \quad \Rightarrow T_2 = ma$$

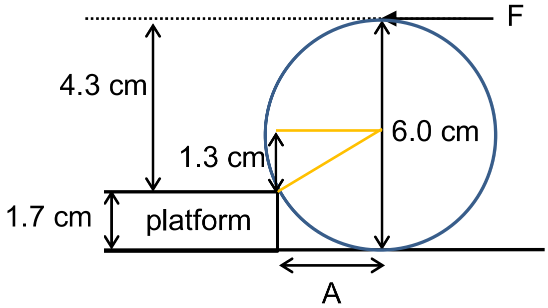
$$\frac{T_1}{T_2} = \frac{3}{1}$$

8 **B** $A = \sqrt{3^2 - 1.3^2} = \dfrac{\sqrt{731}}{10}$

Taking moments about corner of platform:

$F(4.3) = (9.0)(\dfrac{\sqrt{731}}{10})$

$F = 5.7$ N



9 **D** Pressure in a water column is dependent only on the depth of liquid + atmospheric pressure.

10 **B** By COE, loss in E_K = gain in E_P

Since they are launched with the same kinetic energy, both stones will gain the same amount of potential energy when they reach their highest point.

Gain in E_{P1} = Gain in E_{P2}

$$m_1gh_1 = m_2gh_2$$
$$mgh = 2mgh_2$$
$$h_2 = \frac{1}{2}h$$

11 **D** $P = (mg\sin\theta + 240)v = \left[1500 \times 9.81\sin 3.2^0 + 240\right] \times 17$

$= 18.04$ kW $= 18$ kW

12 **(a)** **(i)** unit of t = s — B1

unit of $\dfrac{L \times w \times h}{A\sqrt{2gd}} = \dfrac{\text{m} \times \text{m} \times \text{m}}{\text{m} \times \text{m} \times \sqrt{\text{m s}^{-2} \times \text{m}}} = \text{s}$ — B1

(ii) 1. There may be wrong coefficients. — B1
2. There may be missing or additional terms. — B1

(b) **(i)** Micrometer screw gauge / travelling microscope / digital vernier caliper — B1

(ii)
$$\rho = \frac{\pi\left(0.32 \times 10^{-3}\right)^2 \times 1.60}{4 \times 0.500 \times 0.23}$$ — M1

$= 1.12 \times 10^{-6}$ Ω m — A1

(iii)
$$\frac{\Delta\rho}{\rho} = 2\frac{\Delta d}{d} + \frac{\Delta V}{V} + \frac{\Delta L}{L} + \frac{\Delta I}{I}$$
$$\frac{\Delta\rho}{1.119 \times 10^{-6}} = 2\left(\frac{0.01}{0.32}\right) + \frac{0.02}{1.60} + \frac{0.1}{50.0} + \frac{0.04}{0.23}$$ — M1

$\Delta\rho = 2.81 \times 10^{-7} = 3 \times 10^{-7}$ Ω m — A1

(iv) $\rho = (1.1 \pm 0.3) \times 10^{-6}$ Ω m — B1

(v) Any 1: B1
Use an ammeter/voltmeter with greater precision / resolution / least count
Use a wire of thicker diameter / longer length
Increase potential difference/current

<u>Markers' Comments</u>

(a) **(i)** Students should present their workings clearly.

(ii) Many students have tried to state what is wrong with the derivation of the equation. Only those explanations with the correct physics concepts will be accepted.

(b) **(iii)** The most common mistake made is not rounding off the actual uncertainty to one significant figure. Many students did not use the standard form for their answer, ending up with many zeros in their answer and making careless mistakes.

(v) A common mistake is to suggest taking repeated readings and finding the average of the readings. This method minimises the effects of random error but does not reduce the percentage uncertainty.

13 **(a)** Any 1: B1
Speed is a <u>scalar</u> while velocity is a <u>vector</u>.
Speed has magnitude and <u>no direction</u> while velocity has both magnitude and <u>direction</u>.
Velocity is speed in a specific direction.
Velocity is rate of change of displacement while speed is the rate of change of distance.

(b) **(i)** Parabolic / parabola B1

(ii)
$s = ut + \frac{1}{2}at^2$

$-50 = (7.0\sin 30°)t + \frac{1}{2}(-9.81)t^2$ M1

$t = 3.5694$ or $t = -2.8558$ (rejected)

$t = 3.57$ s

(iii) $u_x = 7.0\cos 30^\circ$ C1

$x = u_x t = (7.0\cos 30^\circ) \times 3.57 = 21.6$ m A1

(iv) $v = u + at$

$v_x = 7.0\cos 30^\circ = 6.062$ m s^{-1}

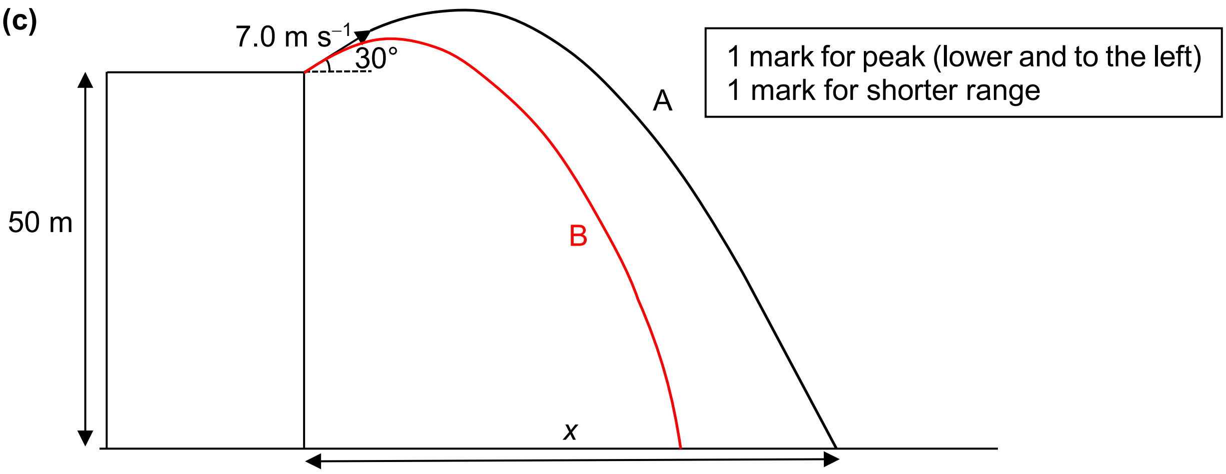
$v_y = 7.0\sin 30^\circ + (-9.81)(3.5694) = -31.52$ m s^{-1} M1

$v = \sqrt{{v_x}^2 + {v_y}^2} = 32.1$ m s^{-1} A1

$\tan\theta = \frac{|v_y|}{|v_x|} = 5.200$ M1

$\theta = 79.1^\circ$ below the horizontal A1

(c)



Markers' Comments

(b) (ii) A few candidates did not define sign convention, and this led to the formation of an incorrect quadratic equation.

(iv) Some candidates used unconventional methods to describe the direction of the final velocity. A well labelled diagram of the final velocity (in the resolved directions) with angle θ labelled clearly would suffice. Workings for the determination of θ should be clearly shown.

(c) Some candidates did not score full credit due to inconsistencies in the range of the parabolic path they drew. The difference in horizontal distance between the 2 paths should be increasing.

14 (a) The rate of change of momentum of a body is proportional to the resultant force acting on it and occurs in the direction of the force. B1 B1

(b) (i)
$$\Delta p = m\Delta v = (1500+80)(0-30) = -47400 \text{ N s}$$
Magnitude = 47400 N M1 A1

(ii)
$$F_{ave} = ma$$
$$\frac{\Delta p}{\Delta t} = ma$$
$$\frac{47400}{\Delta t} = (1500+80)(80)$$ M1
$$\Delta t = 0.375 \text{ s}$$ A1

(iii) The wall exerts an external force on the system. M1
Linear momentum is not conserved. A1

(iv)
$$F_{ave} = ma = (3.0)(80) = 240 \text{ N}$$
or
$$F_{ave} = \frac{\Delta p}{\Delta t} = \frac{(3.0)(30)}{0.375} = 240 \text{ N}$$
M1 A1

(v) The harness provides an extra backward force on the helmet/head. M1

This prevents the head from moving forward while the body is being held/restrained by the seatbelt, thus preventing injury to the neck.
OR
The force on the neck due to the head will be lower. B1

Markers' Comments

(a) This portion was quite well answered.
The common mistakes were that the definition was shortened by omitting words here and there which changed the meaning of the definition entirely.
Missing terms include "**net/resultant** force" and "**rate of** change" to name a few.
Another mistake was that students rearranged the definition to say that the resultant force was proportional to the rate of change of momentum. This implies that the resultant force is brought about by a change in momentum (or a change in the state of an object's motion) and not the other way around.

(b) **(i)** Many students used "change" too casually.
A change in a quantity, by convention in Physics, is used to denote a difference between the final and the initial state, in this case $\Delta p = p_{\text{final}} - p_{\text{initial}}$. Since the object comes to a rest, the change in momentum should have been negative.
Benefit of doubt was given since the question asked for the magnitude.
Other students who correctly calculated the change in momentum sometimes forgot to state the magnitude in the answer line and gave a negative number as the magnitude of a vector which makes no sense.

(iii) There is no need to state the principle of conservation of linear momentum (COLM).
Comparing the total momentum of the car and the dummy before and after the collision is not an application of the principle of conservation of linear momentum.
Stating that the final momentum of the car and the dummy reduces to zero is not a valid application of COLM.
Many students wrongly included the wall as part of the system as well and wrongly concluded that the total momentum of the car, dummy and wall was conserved.

(iv) A common mistake was to use the change in momentum of the car and the dummy (answer in **(b)(i)**) multiplied by the time duration to get the average force. This would give the average horizontal force exerted on the entire system of the car and the dummy **not** the dummy's head.
Some students also calculated the vertical force exerted by the neck on the head instead.

(v) When the car crashes, the head moves forward due to inertia. Since the body is being strapped to the seat by the seatbelt, the body comes to rest faster than the head. The neck needs to provide a larger force to stop the head.
Students were not clear in stating the direction of the forces acting on the neck. Most of them wrongly said that the head causes a backward force on the neck when in fact the head is pulling the neck forward.
It is important to mention that

1) The harness provides a backwards force on the head/helmet or a resistive force on the head/helmet that prevents the head from moving forward due to inertia
2) This keeps the head and body relatively rigid/in the same line
OR this reduces the relative motion between the head and the body
OR this effectively reduces the net forwards force on the head/helmet
thus reducing the strain on the neck.

Just stating "keeping the head in place" or "keeping the body vertical" is too vague.
Some students stated the whole body (assumed to be torso) moves forward due to inertia. In this case, the neck does not exert any additional force on the heard and the harness is not useful.
The head does not experience a collision, so any mentioning of "absorbs" or "cushions" or "the lengthening of time to reduce the force" will be marked wrong. That is the purpose of the helmet, not the harness.

15 **(a)** The weight of an object is the force experienced by the mass of the object in a gravitational field. B1

(b) As the object is in equilibrium, net force on the object is zero.

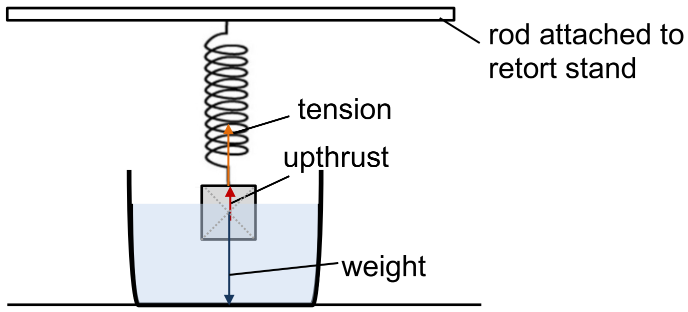
Tension in spring = weight of the object

$$kx = mg$$

$$x = \frac{mg}{k} = \frac{(0.070)(9.81)}{14}$$ M1

$$= 0.0491 = 0.049 \text{ m}$$

(c) **(i)**



3 forces correctly labelled, correct origin, arrow direction. B3

(ii) volume of block $= \frac{m}{\rho} = \frac{0.07}{7780} = 9.00 \times 10^{-6} \text{ m}^3$ C1

Upthrust $= (0.75)\rho g V_{steel}$

$= (0.75)(1000)(9.81)(9.00 \times 10^{-6})$ M1

$= 0.0662$ N A1

(iii) Since block is in equilibrium,

Tension + Upthrust = Weight of steel block

$(14)x + 0.0662 = 0.070 \times 9.81$ M1

$x = 0.0443$ m A1

`

(iv) As oil is less dense than water, hence upthrust on the block is now smaller. M1
Hence for equilibrium, tension and thus extension in the spring will now be larger than **(c)(iii).** A1

Markers' Comments

(a) Generally well done for those who memorised their definitions.
You will need two parts to obtain full credit, firstly the main idea that weight is a FORCE that the object experiences/ is exerted on a mass and secondly, that this mass is placed in a gravitational field. (recall *W* = *F* = *mg*).
Try to use proper terms, masses in general have no 'feelings'.

(c) **(i)** Students must take note of where the forces originate from. Many had upthrust starting from all positions of the cube, when it must start from the centre of buoyancy. Many students did not label their forces in full, only using notations which are undefined.

(c) **(ii)** Generally well done. Some mistakenly used the density for steel when calculating upthrust. Students are highly encouraged to write out the worded equations eg. Upthrust = $(0.75)\rho_{water} g V_{steel}$ before doing their substitutions.

(c) **(iii)** Well done. Many obtained ecf marks for this portion even though **(ii)** is incorrect.

(c) (iv) Many do not know that oil floats on water, and hence is less dense than water. Many students stated that oil is denser that water which is wrong. Although this misconception is rampant, students were able to go on to state with correct physics that (should this scenario true) upthrust is now larger and hence extension is smaller – such a case is awarded 1 mark.
Note that tension is NOT a resultant force. The system is in equilibrium, meaning that there are no net/resultant forces. Stating the presence of a resultant force warrants zero credit.

16 (a) (i) Work done by a force is the product of the force and the displacement in the direction of the force. B1

(ii) To move the mass upwards at constant speed,
the external force F must balance the weight of the mass, i.e. $F = mg$ B1
Change in gravitational potential energy E_p
= work done by F in moving the mass upwards by a vertical distance h
Hence, $E_p = \underline{F \times h} = mg \times h = mgh$ B1

(b) (i)

$$\text{Elastic potential energy} = \frac{1}{2}ke^2 = \frac{1}{2} \times 17.1 \times 0.230^2$$ M1

$$= 0.452 \text{ J}$$ A1

(ii) 1. Let the initial extension e = 0.230 m, the force constant = k,
$M = 0.400$ kg and $m = 0.050$ kg
By energy conservation, gain in ΔEPE = loss in GPE

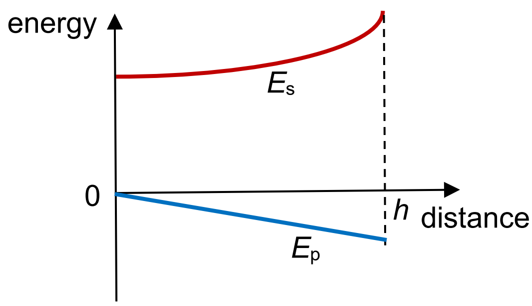
$$\frac{1}{2}k(e+h)^2 - \frac{1}{2}ke^2 = (M+m)gh$$ B1

$$\frac{1}{2}k\left[e^2 + h^2 + 2eh - e^2\right] = (M+m)gh$$ M1

$$\frac{1}{2}kh(h+2e) = (M+m)gh$$

$$h = \frac{2(M+m)g}{k} - 2e = \frac{2(0.400+0.050)9.81}{17.1} - 2 \times 0.230 = 0.0563 \text{ m}$$ A1

2.



E_s is parabolic in shape, does not pass through the origin, B1
E_p is a straight line of negative gradient passing through the origin and lies below the x-axis. B1
the decrease in E_p is the same as the increase in E_s at h. B1

Markers' Comments

16 **(a)** **(i)** Quite a number of students left out the phrase "in the direction of the force".

(ii) Many students did not mention that to move the mass upwards at a constant speed, the applied force on the mass upwards has to be equal to the weight *mg*.

(ii) Very few students answered this part correctly. Common mistakes are:

Many used $\frac{1}{2}kh^2 = mgh \rightarrow \therefore h = 0.516$ m, forgetting that the spring had an initial extension, and therefore an initial elastic potential energy.

There were also many who used $mg = kh \rightarrow \therefore h = \frac{mg}{k} = \frac{0.450 \times 9.81}{17.1} = 0.258$ m, not realizing that if the mass is suddenly released, the spring will over-extend.

(iii) Very few students drew all the graphs correctly. Again, they forgot that the spring had an initial EPE, so the E_s graph should not start at 0.

17 **(a)** The concentration <u>decreases </u>with height with a <u>decreasing rate</u>. M1 A1

(b) **(i)** **1.** Point plotted to within half of smallest square (0.300, 63.430) A1

2. Best fit line drawn correctly A1

(ii) Using the points (0.020, 63.840) and (0.660, 62.900), M1

$$\text{gradient} = \frac{63.840 - 62.900}{0.020 - 0.660} = \frac{0.940}{-0.640} = -1.469 = -1.47$$ A1

(c) **(i)** n_0 is the <u>concentration at $h = 0$ </u>OR the <u>maximum concentration</u>. B1

(ii) Linearization of $n_h = n_0 e^{-mgh/kT}$ yields a linear function with a negative gradient and a y-intercept. The graph of Fig. 17.2 has a <u>negative gradient</u> and a <u>y-intercept</u>, which supports the proposal. B1 B1

(iii) C1

$$n_h = n_0 e^{-mgh/kT} \Rightarrow \ln n_h = -\frac{mg}{kT}h + \ln n_0$$

$$\text{gradient} = -\frac{mg}{kT}$$

$$-1.47 = -\frac{m \times 9.81}{1.38 \times 10^{-23} \times 273}$$ M1

$$m = 5.65 \times 10^{-22} \text{ kg}$$ B1

Markers' Comments

(a) A number of students speculated that the graph is linear for certain range of values for *h*. By using a ruler to check, it is clear that the curve is nonlinear throughout.

(b) **(i)** **1.** The allowed error margin for reading off coordinates and plotting of points are both "half of the smallest square". But if you had taken maximum advantage of this error margin when you read off the coordinates on Fig. 17.1 AND when you plotted the points on Fig. 17.2, the plotted point will be too far off, and you WILL lose your mark here.

Some students wrongly stated that there is an "inverse relationship" between n_h and *h*. You cannot distinguish, for example, the curves $n_h = 1/h$ (the inverse relationship) and $n_h = n_0 \exp(-h)$ through eyeballing. Refrain from using a technical term (such as "inverse relationship") unless you are absolutely certain about it.

2. Best-fit line (BFL) must be balanced, with roughly equal number of points above and below it (differing by 1 is ok, 2 is one too many.). The second common mistake is that some BFL did not capture the correct gradient. For example, if left-most points are above the BFL, while the right-most points are below it, then your BFL leads to a smaller (more negative in this case) gradient.

(ii) Both horizontal and vertical coordinates should be to 3 d.p.. The final answer should have 3 s.f.. The two points chosen should be separated by at least half of the available graphing area (4 big squares horizontally, 6 vertically).

(c) **(i)** The concentration in this question is that of the steady state, i.e. it does not change with time. So n_0 is the concentration at $h = 0$ m (h being the height from the bottom of the region) and is constant in time. Phrases such as "initial", "beginning" or "original" all hint at time-dependence and no mark is awarded.

(ii) Marks are awarded for "linear relationship" and "negative gradient". If, for example, the actual function was $n_h = \frac{n_0}{h}$, then plotting $\ln n_h$ against h would not yield a linear function (n_h against $1/h$ would then be linear). Hence, the linearity of $\ln n_h$ against h is important, so is the negative gradient.

(iii) One major mistake made by some students is to calculate m by substituting the coordinates of a single point on Fig. 17.1 into the equation $n_h = n_0 e^{-\frac{mgh}{kT}}$. You are to use your answer in **(b) (ii)**. The gradient, which is calculated by taking into account all the plotted points (when plotting the BFL), is a result of averaging over the random errors of the points. Hence, using the gradient is more reliable than using the coordinates of a single point.