DUNMAN HIGH SCHOOL
2021 PHYSICS H2 (YEAR 5)

Answers to Promotional Exam

Section A

1	2	3	4	5	6	7	8	9	10
C	B	C	A	C	B	D	B	A	D
11	**12**	**13**	**14**	**15**	**16**	**17**	**18**	**19**	**20**
D	A	C	D	D	A	B	A	C	B

1 C

mass of 20c coin: 3.85 g or about 4×10^{-3} kg (Order of magnitude 10^{-3} kg)
thickness of a sheet of paper: 0.1 mm or 1×10^{-4} m (Order of magnitude 10^{-4} m)
an average apple has a mass of 100 g or weight of 1 N (Order of magnitude 10^{0} N)
temperature of a person's body: 36.5 °C or 310 K or 3×10^{2} K (Order of magnitude 10^{2} K)

2 B

$f = Cm^p k^q$

in terms of base units: $\text{s}^{-1} = \text{kg}^p \left(\text{kg s}^{-2}\right)^q$

comparing the exponent:

of s: $-1 = -2q \Rightarrow q = \frac{1}{2}$

of kg: $0 = p + q \Rightarrow p = -q = -\frac{1}{2}$

3 C

X = P – R ⇒ X = P + (−R) ⇒ vector addition of P and –R, i.e. the beginning of vector −R is placed at the end of vector P; the vector sum X is drawn as the vector from the beginning of P to the end point of –R.

4 A

After releasing from rest, the mass slides down the inclined surface with constant acceleration $a = g\sin 30^\circ$.

Using $s = ut + \frac{1}{2}at^2$, we have

$s = (0)(0.80) + \frac{1}{2}\left(g\sin 30^\circ\right)(0.80)^2 = 1.6$ m (to 2 s.f.)

5 C

Using $v^2 = u^2 + 2as$ for uniform acceleration along the vertical direction, and taking upward direction as positive, we have

$0^2 = (v\sin\alpha)^2 + 2(-g)H$

$\Rightarrow H = \dfrac{(v\sin\alpha)^2}{2g}$

6 B

force = rate of change of momentum = gradient of momentum-time graph. Since the resultant force is increasing, the graph has increasing gradient with time.

7 D

action-reaction forces act on different objects and are of the same type of force.

8 B

at equilibrium W = U

$$32 = (0.012)(0.3)\,\rho\,(9.81)$$

$$\rho = 910 \text{ kg m}^{-3}$$

9 A

When tension = 400 N, length = 37 mm and extension = 2 mm.

strain energy = $\frac{1}{2}Fx = \frac{1}{2}(400)(2 \times 10^{-3}) = 0.40$ J

10 D

This equation is not valid as there is an acceleration.

11 D

efficiency = useful power output/ power input

= (260/320) x 100 = 81%

12 A

At highest point, T is lowest (=0) and speed is minimum.

$T + mg = mv^2/r$

so $g = v^2/r$ or $v = \sqrt{rg} = \sqrt{(0.25(9.81)} = 1.6 \text{ m s}^{-1}$

13 C

When released from P, the direction of motion is towards planet A, in the direction of lower potential.

By conservation of energy, loss in potential energy = gain in kinetic energy

$$m\Delta\phi = \frac{1}{2}mv^2$$

$$v = \sqrt{2(\Delta\phi)} = \sqrt{2(62.3 - 13.4) \times 10^6}$$

$$= 9.89 \times 10^3 \text{ m s}^{-1}$$

14 D

total energy = $-GMm/2r$, potential energy = $-GMm/r$, kinetic energy = $GMm/2r$

As r increases, total energy and potential energy increases while kinetic energy decreases

15 D

Isothermal processes do not change U as temperature is constant, $\Delta U_1 = 0$.

Thus, $Q = -W_1$

However, an adiabatic compression will cause temperature to increase as state of gas moves to a higher isotherm, so U will increase. Note that $\Delta U_2 = W_2$ since $Q = 0$

We find that $|W_1| < |W_2|$ (from area under graph), so $\Delta U_1 + \Delta U_2 = \Delta U_2 > Q$, so the answer is D.

16 A

The rate of heat loss of the hot liquid is constant during cooling before solidification and during the freezing

During cooling:

$$Pt = mc\Delta\theta$$

$$P(1) = mc(4.0)$$

During freezing:

$$Pt = ml_f$$

$$P(25) = ml_f$$

$$\frac{P(1)}{P(25)} = \frac{mc(4.0)}{ml_f}$$

$$\frac{c}{l_f} = \frac{1}{25} \times \frac{1}{4.0} = 0.01$$

17 B

Since product of pV for T_2 is four times that of T_1, complied with the fact that $pV = nRT$, T_2 is four times that of T_1.

Since $\frac{1}{2}m\langle c^2\rangle = \frac{3}{2}kT$, $c_{rms} \propto \sqrt{T}$

$$\frac{c_2}{c_1} = \frac{\sqrt{T_2}}{\sqrt{T_1}} = \frac{2}{1}$$

18 A

Same current flows through both lamps in series. Hence, $P \propto R$.

$$\frac{P_X}{P_Y} = \frac{R_X}{R_Y} = \frac{V_X}{V_Y}$$

$$\frac{1}{3} = \frac{V_X}{24 - V_X}$$

$$V_X = \frac{24}{4} = 6 \text{ V}$$

19 C

Consider a fixed point, $4Q$ will pass through the point in one period.

So, $\textbf{current} = \dfrac{\textbf{total charge}}{\textbf{time}} = \dfrac{4Q}{1/f} = 4Qf$

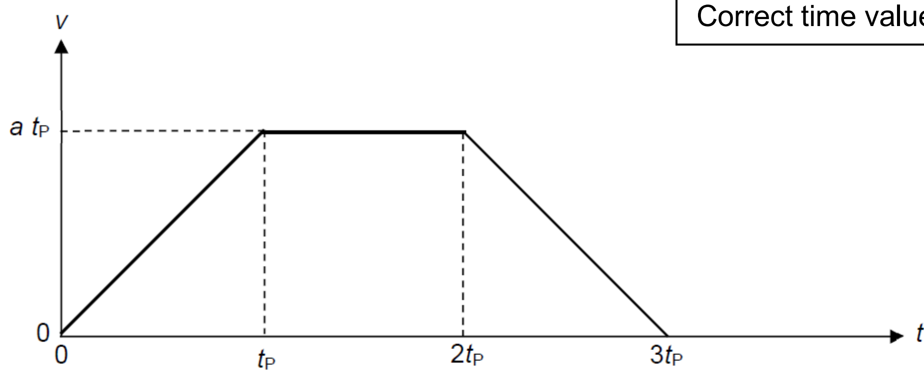
20 B

$E_{batt} = VIt$
$18.0 = \varepsilon(0.025)(80)$
$\varepsilon = 9.0$ V
$E_r = I^2 rt$
$18.0 - 11.0 - 4.0 = 0.025^2 r(80)$
$r = 60\ \Omega$

Section B

1 **(a)**

Correct shape	[A1]
Correct time values	[A1]

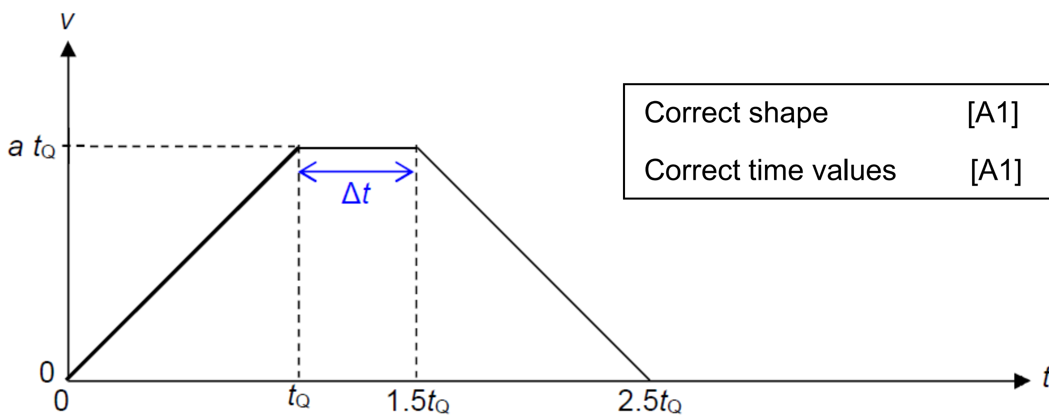


(b) **(i)** **1.** $\frac{(at_Q)(t_Q)}{2} = \frac{at_Q^2}{2}$ [A1]

same distance for each third of journey:

2. $\frac{at_Q^2}{2} = (at_Q)(\Delta t) \Rightarrow \Delta t = 0.5t_Q$ [A1]

(ii)



Correct shape	[A1]
Correct time values	[A1]

(c) Since distance travelled by both trains is the same,

$(2t_P)(at_P) = (1.5t_Q)(at_Q)$ [C1]

$\frac{t_Q}{t_P} = \sqrt{\frac{4}{3}}$ [C1]

$\frac{\text{total time taken by train Q for the journey}}{\text{total time taken by train P for the journey}} = \frac{2.5t_Q}{3t_P} = \left(\frac{2.5}{3}\right)\sqrt{\frac{4}{3}}$ [C1]

= 0.962 [A1]

*Marker's comments: Most have drawn part **(a)** graph correctly. Part **(b) (i)** expressions were generally written correctly by majority of candidates, though, for part **(b) (ii)**, some did not draw the second third of the journey having half the time interval of the first third. Part **(c)** proved difficult for some candidates. Either they calculated an incorrect total time taken by each train, or did not calculate correctly the ratio t_Q/t_P.*

2 **(a)** **(i)** gain in kinetic energy = loss in gravitational potential energy

$\frac{1}{2}mv^2 = mgh$ [C1]

$\frac{1}{2}v^2 = 9.81\ (4.5)$

$v = 9.4\ \text{m s}^{-1}$ [A1]

Alternative method: Using equation of motion for constant acceleration,

$v^2 = u^2 + 2as$ [C1]

$= 0 + 2\ (9.81)(4.50)$

$v = 9.40\ \text{m s}^{-1}$ [A1]

(ii) $p = mv = (250)\ (9.40) = 2350\ \text{kg m s}^{-1}$ [A1]

(iii) Using conservation of momentum,

$2350 = 2250V$ [C1]

$V = 1.04\ \text{m s}^{-1}$ [A1]

(b) **(i)** loss in k.e. = $\frac{1}{2}mv^2 = \frac{1}{2}(2250)(1.04)^2$ [C1]

$= 1220\ \text{J}$ [A1]

Marker's comments: loss in kinetic energy does not equal to gain in potential energy due to the presence of frictional forces. In this case, there is also loss in gravitational potential energy besides the loss in kinetic energy.

(ii) work done by frictional force = loss in kinetic energy + loss in potential energy

$F(0.25) = 1220 + 2250\ (9.81)(0.25)$ [C1]

$F = 2.7 \times 10^4\ \text{N}$ [A1]

Marker's comments: many students forget to include the loss in gravitational potential energy.

Alternative method: Using equation of motion for constant acceleration,

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

$0 = (1.04)^2 + 2a(0.25)$

$a = -2.2\ \text{m s}^{-2}$ [C1]

Using Newton 2nd law: $W - F = -ma$

$F = W + ma = 2250\ (9.81 + 2.2) = 2.7 \times 10^4\ \text{N}$ [A1]

(c) As pile gets deeper in the ground, friction from the ground will increase. [B1]
The loss in kinetic energy of the hammer and pile is the same. [B1]

Marker's comments: the loss in kinetic energy is the same as the hammer is raised to the same height each time.

3 **(a)** It is a single point where the weight of the object appears to act. [B1]

(b) **(i)** take moments about front wheel,

P (90) = 160 (50) [C1]

P = 89 N [A1]

Marker's comments: students are encouraged to mention the point where moment is calculated in their answers. In some answers, there is a need to explain why 40P = 50Q is used.

(ii) resultant force = 0 or $P + Q = 160$ [M1]

Q = 71 N [A1]

(iii) take moments about rear wheel,

force F x 10 = 160 (40) [C1]

F = 640 N [A1]

Marker's comments: when the front wheels are lifted off the ground, Q = 0. Thus moments should be taken about the rear wheel to calculate the force to be applied at A.

(c) The distance of pivot from A is larger, [M1]
less force is needed. [A1]

4 **(a)** It is the region in space in which a mass experiences a force. [B1]

Marker's comments: there was confusion with gravitational field strength or gravitational potential with gravitational field. In addition, due to the 3D world, it refers to the space (rather than area) where the mass (not object) experiences a force.

(b) **(i)** $\omega = \frac{2\pi}{T} = \frac{2\pi}{44.2 \times 365 \times 24 \times 3600}$ [M1]

$= 4.5 \times 10^{-9}$ rad s^{-1} [A1]

(ii) gravitational forces are equal or centripetal force about P is the same [C1]
Hence $M_1 x\omega^2 = M_2(d-x)\omega^2$ [M1]

$\frac{M_1}{M_2} = \frac{d-x}{x}$ [A0]

Marker's comments: the gravitational potential from both stars are NOT the same at P.

(iii) Gravitational force provides centripetal force [C1]

$$\frac{GM_1M_2}{d^2} = M_2\,(d - x)\omega^2$$ [M1]

or $GM_1 = d^2\,(d - x)\,\omega^2$ [A0]

Marker's comments: being "show" type of questions, the reasons why the equations are used must be given.

(iv) $x = 0.4d$ [C1]

$GM_1 = (0.6)(1.8 \times 10^{12})^3\,(4.5 \times 10^{-9})^2$ [M1]

$M_1 = 1.1 \times 10^{30}$ kg [A1]

Marker's comments: some students misunderstood 1.5 as $\frac{1}{5}$

5 **(a)** In an ideal gas, intermolecular forces are negligible and hence no intermolecular potential energy is present. [B1]

Hence the internal energy of an ideal gas is the sum of random distribution of kinetic energies of the gas molecules. [B1]

Marker's comments: most did not mention why PE = 0, hence only marks for KE was awarded.

(b) **(i)** Using $pV = nRT$

Since pressure is constant, V is proportional to T for a fixed mass of gas.

$V_1 / V_2 = T_1 / T_2$

$T_2 = (1500/1000) \times (273.15 + 20)$ [C1]

$= 440$ K $= 167$ °C [A1]

Marker's comments: Common mistake was forgetting to convert 20°C to K, so final temperature became 30 rather than 167.

(ii) No. of moles = PV/RT

$= 1.01 \times 10^5 \times 0.001000 / 8.31 \times 293.15 = 0.0415$ moles [C1]

$N = 0.0415 \times 6.02 \times 10^{23}$

$= 2.5 \times 10^{22}$ particles [A1]

Marker's comments: 'error carried forward' if used temperature from part (i). Some left answer in moles.

(iii) $\Delta U = 3/2\, Nk\Delta T$ [C1]

$= 76$ J [A1]

Marker's comments: Some calculated 3/2 NkT rather than 3/2 NkΔT. Some did not have 3/2 or N.

(iv) $W = -P\Delta V = -1.01 \times 10^5 \times (500 \times 10^{-6}) = -50.5$ J [C1]

$Q = \Delta U - W = 76 + 50.5$

$= 126$ J (accept 127 J) [A1]

Marker's comments: *Common mistake was forgetting minus sign for W. i.e. 50.5 rather than –50.5J. 'error carried forward' for using ΔU from part (iii)*

6 (a) (i) $p = mu$ [A1]

(ii) $\Delta p = p_f - p_i$ [C1]

$= mu - (-mu)$

$= 2mu$ (or $-2mu$) [A1]

Marker's comments: *Most students can identify part (i) and (ii) as mu and 2mu respectively.*

(iii) $t = 2l/u$ [A1]

Marker's comments: *Common mistake was forgetting factor of 2.*

(iv) $N / t = N / (2l/u)$ [C1]

$= Nu / 2l$ [A1]

Marker's comments: *Some wrote N (2l) / u instead. Others tried using momentum, i.e. mu in the answer but m is actually not needed here.*

(v) $N / t \times \Delta p = (Nu / 2l) \times 2mu = Nmu^2 / l$ [A1]

Marker's comments: *'error carried forward' if part (ii) and part (iv) answers used here.*

(vi) $P = \frac{F}{A}$

$= \frac{Nmu^2}{lA}$

$= \frac{Mu^2}{V}$ [A0]

since $Nm = M$ and $lA = V$ [C1]

Marker's comments: *many did not realise the M in final answer is capital M, and chose to use small m, which is incorrect, since M is mass of gas while m is mass of 1 molecule.*

(b) three dimensions (results in a factor of 1/3) [B1]

different speeds (makes it necessary to use $\langle c^2 \rangle$) [B1]

Marker's comments: *Many students noted 1 of the above factors, either random directions or speeds, and few managed to mention both factors. Many also mentioned what they learned about ideal gas in chemistry, i.e. gas behaves like ideal gas at high T and low P, but this is irrelevant to* *the question. Continuous random motion was also mentioned often, but this does not award full marks as it does not explicitly mention different speeds + directions.*

7 (a) (i) $A\rho g$ / m is a <u>constant</u> and so acceleration proportional to x [B1]

<u>negative sign</u> shows acceleration towards a fixed point / in opposite direction to displacement [B1]

(ii) identifies ω^2 as $A\rho g$ / m and therefore s.h.m. can be implied [B1]

$2\pi f = \omega$ [B1]

Hence $f = \dfrac{1}{2\pi}\sqrt{\dfrac{A\rho g}{m}}$ [A0]

*Marker's comments: For **(a) (i)**, many candidates did not explain but just defined s.h.m.*

(b) (i) 1 0.500 cm [A1]

2 T = 0.800 s [A1]

(ii) $\omega = 2\pi / T$ [C1]

= 7.85 rad s^{-1}

correct use of $v = \omega\sqrt{x_0^2 - x^2}$ [B1]

$= 7.85 \times \sqrt{0.500^2 - 0.200^2}$

= 3.60 cm s^{-1} [A1]

or

(if tangent drawn or clearly implied *[B1]*

3.6 ± 0.3 cm s^{-1} *[A2]*

but allow 1 mark for > ±0.3 but ≤ ±0.6 cm s^{-1})

(iii)

$\omega^2 = \dfrac{\rho A g}{m} \Rightarrow 2\pi f = \sqrt{\dfrac{\rho A g}{m}}$ from **(a) (ii)**

$\Rightarrow 2\pi(1.25) = \sqrt{\dfrac{(1.0\times10^3)(4.2\times10^{-4})(9.81)}{m}}$ [C1]

$m = 6.7\times10^{-2}$ kg [A1]

, or

When the tube is floating as in **Fig. 7.1 a**,

$mg = \rho g(LA)$ [M1]

$m = \rho LA$

= (1.0 × 10^3)(16.00 × 10^{-2}) (4.2 × 10^{-4})

= 6.7 × 10^{-2} kg [A1]

*Marker's comments: For **(b) (ii)**, the common mistake was to use value of L for x to compute v. For **(b) (iii)**, the common mistake being incorrect conversion from cm^2 to m^2 for cross-sectional area of the tube.*

(c) **(i)** Assume the oscillation obeys the expression in part **(a) (ii)**:

$$\frac{1}{T} = \frac{1}{2\pi}\sqrt{\frac{\rho A g}{m}} \Rightarrow \frac{1}{T} \propto \sqrt{\rho}$$ [C1]

From the graph, $1/T_{liquid} = 1/0.600$ s [M1]

$$\Rightarrow \sqrt{\frac{\rho_{liquid}}{\rho_{water}}} = \frac{1/T_{liquid}}{1/T_{water}} \Rightarrow \sqrt{\frac{\rho_{liquid}}{1.0 \times 10^3}} = \frac{1/0.600}{1/0.800} \Rightarrow \rho_{liquid} = 1.8 \times 10^3 \text{ kg m}^{-3}$$ [A1]

(ii) Viscous forces (fluid friction) between the liquid and the tube opposes the motion of tube as it oscillates [B1]

(it acts as a dissipative force causing the mechanical energy of the tube to decrease continuously)

(iii) Energy of oscillations is proportional to (amplitude)^2:

$$E = \frac{1}{2}\left(m\omega^2\right)x_0^{\,2} \text{ or } \frac{1}{2}\left(A\rho g\right)x_0^{\,2}$$ x_o: amplitude at t = 1.2 s

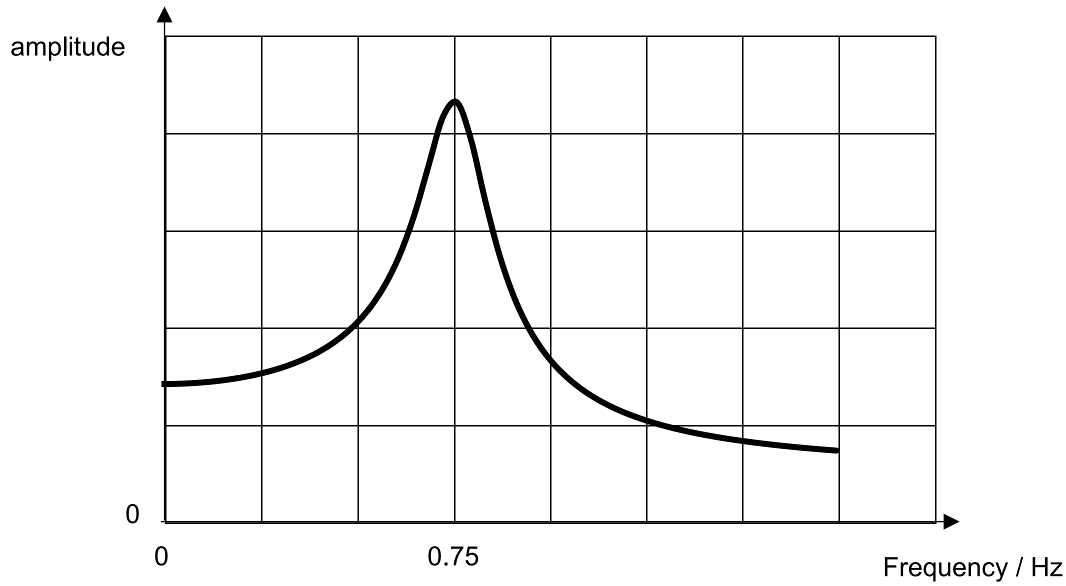
$$= \frac{1}{2}(0.067 \text{ kg})\left(\frac{2\pi}{0.60 \text{ s}}\right)^2\left(0.20 \times 10^{-2} \text{ m}\right)^2$$ [M1]

$$= 1.5 \times 10^{-5} \text{ J}$$ [A1]

*Marker's comments: For **(c) (ii)**, many referred to friction or viscous forces without giving any information as to where these forces act. Some thought that the upthrust would act as a dissipative force. For **(c) (iii)**, some candidates calculated a value for v at 1.2 s using the expression v = ωx and then found kinetic energy using ½ m v^2. This may give the correct numerical value but, in this part of question, the speed is zero at 1.2 s. Among those who quoted the correct expression, some did not convert the amplitude given in cm into m.*

(d) **(i)** Resonance occurs when the resulting amplitude of the system becomes a maximum when the driving frequency of external driving force equals to natural frequency of the system. [B1]

(ii)



Correct shape (non- symmetrical; non-zero amplitude at 0 Hz)	[B1]
Max amplitude at 0.75 Hz	[B1]

*Marker's comments: For **(d) (i)**, candidates must include enough detail in the explanation.*