DUNMAN HIGH SCHOOL
2023 PHYSICS H2 (YEAR 5)

Answers to Promotional Exam

Section A

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

1 A

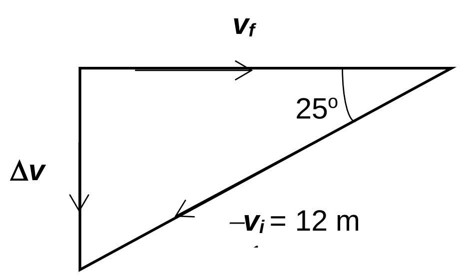
Energy produced = $Pt = 3.0 \times 10^{9} \times 2.0 \times 10^{-12}$

$= 6.0 \times 10^{-3}$ J

$= 6.0 \times 10^{-15}$ TJ

2 B

Recall: $\Delta \boldsymbol{v} = \boldsymbol{v_f} - \boldsymbol{v_i}$



The horizontal component of $\boldsymbol{v_i} = \boldsymbol{v_f}$ since there's no horizontal acceleration, so $\Delta \boldsymbol{v}$ is vertical.

$\Delta \boldsymbol{v} = 12 \sin 25^{o} = 5.1$ m s^{-1}

3 C

Using: $s = ut + \frac{1}{2}at^2$

On Moon:

$$3 = \frac{1}{2}a_{moon}t^2 \;---(1)$$

On Earth:

$$2 = \frac{1}{2}(6a_{moon})t_{Earth}^2 \;---(2)$$

Solving (1) and (2),

$$\frac{2}{3} = \left(\frac{6a_{moon}}{a_{moon}}\right)\frac{t_{Earth}^2}{t^2}$$

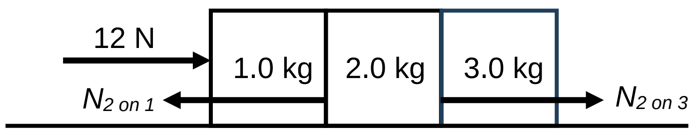
$$t_{Earth} = \frac{t}{3}$$

4 B

Before time instant B, the cars move towards each other.

After time instant B, the cars move away from each other.

5 C



The acceleration of the system can be found by $m_{total}a = 12$.

$\therefore a = 2.0 \text{ m s}^{-1}$

Considering the forces acting on the 1.0 kg mass,

$$\begin{aligned} 12 - N_{2\text{ on }1} &= m_1 a \\ N_{2\text{ on }1} &= 12 - 1.0(2.0) \\ &= 10 \text{ N} \end{aligned}$$

Considering the forces acting on the 3.0 kg mass,

$$\begin{aligned} N_{2\text{ on }3} &= m_3 a \\ &= 3.0(2.0) \\ &= 6.0 \text{ N} \end{aligned}$$

6 C

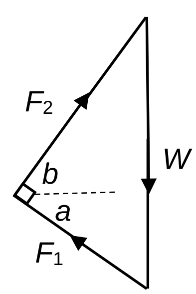
At equilibrium, the 3 forces on the object formed a closed triangle.

By Pythagoras theorem, $\sqrt{F_1^2 + F_2^2} = 100$. That would rule out A and B.

Since the net force on the object is zero, then horizontally,

$F_1 \cos a = F_2 \cos b$

Since $b > a$, $\cos b < \cos a$, so $F_2 > F_1$



7 **D**

Fully submerged: $U_{full} = V_{disp\ water}\rho_{water}g = V_{ice}\rho_{water}g$

Floating (at equilibrium) $U_{float} = W_{ice} = m_{ice}g = V_{ice}\rho_{ice}g$

Hence $\dfrac{\text{upthrust when fully submerged}}{\text{upthrust when floating}} = \dfrac{\rho_{water}}{\rho_{ice}} = 1.1$

8 **D**

$D = kv^2$ where k is a constant of proportionality

At 12 m s^{-1}, the driving force provided by the 2 engines is equal and opposite to the total drag.

$$P = Dv$$
$$36000 \times 2 = k(12)^3$$
$$k = \frac{720000}{(12)^3}$$

If only 1 engine is on, the new maximum speed v' can be found by:

$$360000 = \frac{720000}{(12)^3}(v')^3$$
$$v' = \sqrt[3]{\frac{360000}{720000}(12^3)}$$
$$= \frac{12}{\sqrt[3]{2}}$$
$$= 9.5 \text{ m s}^{-1}$$

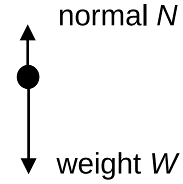
9 **A**

Since they are rotating together with the horizontal turntable without slipping, the angular velocity of the two coins is the same as that of the horizontal turntable,

$$\therefore \omega_1 = \omega_2$$
$$\frac{\omega_1}{\omega_2} = 1$$

$$\frac{v_1}{v_2} = \frac{r_1\omega}{r_2\omega}$$
$$= \frac{r_1}{r_2}$$

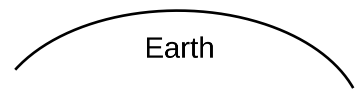
10 **D**



Consider forces acting on man of mass m when in orbit,

$$W - N = \frac{mv^2}{r} \qquad (1)$$

Since the space station and man (total mass M) is in orbit around the Earth,

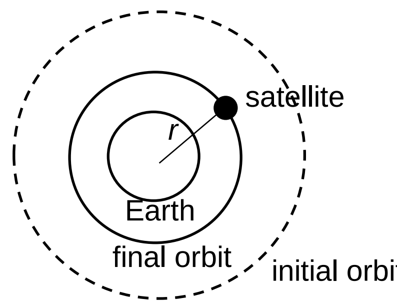


$$\frac{GMm}{r^2} = \frac{Mv^2}{r} \qquad (2)$$

or $\frac{Gm}{r^2} = \frac{v^2}{r}$ i.e. $g = a_c$ (3)

Sub (3) into (1) gives $N = 0$ i.e. weight provides the centripetal force

11 **A**



gravitational force $F = \frac{GMm}{r^2} = (mr\omega^2 = \frac{mv^2}{r})$ (1)

gravitational potential energy $U = -\frac{GMm}{r}$

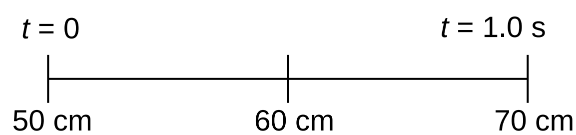
As radius of orbit r decreases,

F increases, U decreases (as it is more negative). That would rule out C and D.

Since F increases, from equation (1), ω increases. That would rule out B.

Also from equation (1), linear speed v increases.

12 **D**



Use $x = -x_o \cos \omega t$

$$= -10 \cos \frac{2\pi(1.25)}{2}$$

$$= 7.1 \text{ cm}$$

Hence the particle is displaced 7.1 cm to the right from the equilibrium position (60 cm).

13 B

$E_K = \frac{1}{2}mv^2 = \frac{1}{2}mv_o^2(\sin^2\omega t)$

From the graph, period T of motion = 2.0 s and maximum E_K = 88 J

So $\frac{1}{2}(3.0)v_o^2 = 88$ or $v_o = \omega x_o = 7.66$ m s^{-1}

Since $\omega = \frac{2\pi}{T} = \pi$, then $x_o = 2.44$ m

Maximum acceleration = $\omega^2 x_o$

$= \left(\frac{2\pi}{2}\right)^2 (2.44) = 24$ m s^{-2}

14 C

Option D is incorrect since the current is the same in both sections.

Since $R = \frac{\rho l}{A} \Rightarrow \frac{R}{l} = \frac{\rho}{A} \Rightarrow \frac{R}{l} \propto \frac{1}{A}$ (ρ is constant for same material), resistance per unit length of the narrow section is twice that of wide section since the constant current flows through the narrower section.

Since $V \propto R$ for constant l, the resistor with the larger resistance has a larger p.d. across it. Hence, the narrower section (with larger resistance per unit length), has larger p.d. per unit length across it. Hence options A and B are wrong.

15 B

The decrease in temperature will cause an increase in the resistance of the thermistor while the increase in light intensity will cause a drop in the resistance of the LDR.

Since V_1 is independent of the change in resistance of the thermistor, most of the current must have passed through a real diode for a short time duration instead of the LDR or a fixed resistor.

Section B

1 **(a)** Speed is a physical quantity and can only be defined in terms of other physical quantities. B1

Distance is a physical quantity, but **second is a unit for time** which cannot be used to define speed. B1

(b) Time to reach maximum height, $t = \dfrac{u\sin\theta}{g}$ M1

Time of flight, $T = 2t = \dfrac{2u\sin\theta}{g}$ A1

$$= (u\cos\theta)(T)$$

$$= (u\cos\theta)\left(\frac{2u\sin\theta}{g}\right)$$ M1

$$= \frac{2u^2\sin\theta\cos\theta}{g}$$ A0

(c) Maximum R occurs when $\sin 2\theta = 1$.

Hence $\theta = 45^o$ A1

(d) $R_0 = \dfrac{u^2}{g}$

$$= \frac{45.36\text{ km}}{\text{h}} = \frac{45.36\ (1000)\text{ m}}{(60)(60)\text{ s}} = 12.6\text{ m s}^{-1}$$ C1

$$g = \frac{u^2}{R_0}$$

$$= \frac{(12.6)^2}{16.3}$$

$$= 9.7399\text{ m s}^{-2}$$ A1

$$\frac{\Delta g}{g} = 2\frac{\Delta u}{u} + \frac{\Delta R_0}{R_0}$$

$$\frac{\Delta g}{9.7399} = \frac{2(3\%) + 4\%}{100\%}$$

$$\Delta g = 0.97$$

$$= 1\text{ m s}^{-2}$$ A1

Therefore, $g = (10 \pm 1)\ \text{m s}^{-2}$ A1

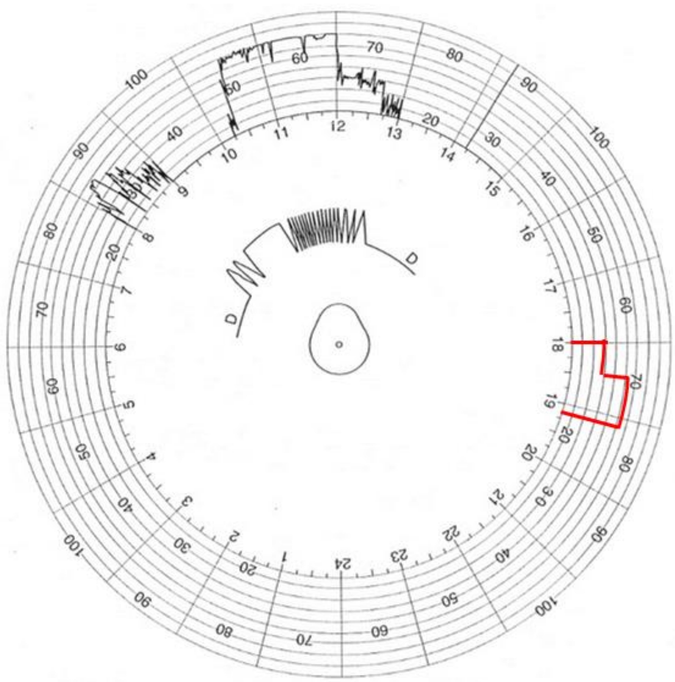
2 **(a)** **(i)** 80 km h^{-1} A1

(ii) 1.25 hours (between 09.00 and 10.15) A1

(b) **(i)** Between 10.15 and 10.30, the lorry accelerates steeply from rest but appears to **hit a speed limit of 80 km h^{-1} beyond which it is not able to exceed**. A1

(ii) Between 12.45 and 13.00, the lorry **keeps speeding up and slowing down very frequently**. The **average speed is extremely low, around 20 km h^{-1}**. A1

(c)



A1 - for three correct traces

A2 - for five correct traces

(d) Average speed between 12.00 and 12.45 is 40 km h^{-1}, hence the distance travelled within this time of 45 minutes is (40 km h^{-1})(0.75 h) = 30 km.

Average speed between 12.45 and 13.00 is 20 km h^{-1}, hence the distance travelled within this time of 15 minutes is (20 km h^{-1})(0.25 h) = 5 km. M1

The total distance travelled between 12.00 and 13.00 is 30 km + 5 km = **35** km. A1

(e) **(i)** 14.15 is the time the tachograph reading shoots to the maximum of 100 km h^{-1}.

A1

(ii) This is to **distinguish the switched-off period from periods when the lorry is not moving** (e.g. at red traffic lights). B1

There is no way the lorry could have reached a maximum speed of 100 km h^{-1} since it is limited to 80 km h^{-1}. Hence a recorded maximum speed of 100 km h^{-1} can only mean that the tachograph has been switched off.

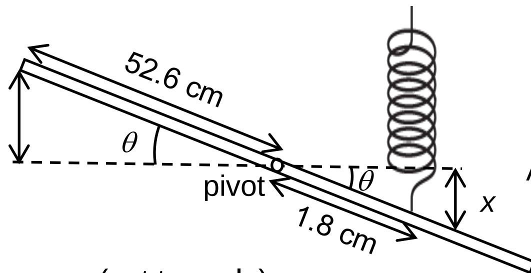
3 **(a)** The *moment of a force* <u>about a point</u> is the product of the magnitude of the force and the <u>perpendicular</u> distance from the line of action of the force <u>to that point</u>. B1

(b) **(i)** distance moved by pointer = 123 – 86 = 37 mm M1

$\sin\theta = \frac{x}{1.8} = \frac{37}{52.6}$ M1

$x = \frac{37}{52.6}(1.8)$

$= 1.3$ mm A0



(not to scale)

or

$\sin\theta$ or $\tan\theta = \frac{3.7}{52.6}$

or $\theta = 4.0°$ M1

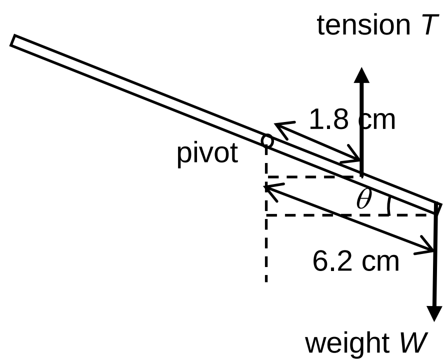
$x = 1.8 \sin\theta$ or $\tan\theta = 1.3$ mm A0

(ii) Magnitude of the moment of the weight about pivot,

$= W\,(6.2 \times 10^{-2} \cos\theta)$

$= (0.492)(9.81)(6.2 \times 10^{-2} \cos 4.0°)$ C1

$= 0.30$ N m A1



(iii) At equilibrium,

clockwise moment about pivot = anti-clockwise moment about pivot

$0.30 = T\,(1.8 \times 10^{-2} \cos 4.0°)$ M1

$T = 17$ N A1

(iv) Using Hooke's Law,

$F = kx$

$17 = k\,(1.3 \times 10^{-3})$ C1

$k = 1.3 \times 10^{4}$ N m^{-1} A1

4 **(a)** The gravitational field strength at a point is the gravitational force exerted per unit mass placed at that point. – follow definition in notes B1

(b) **(i)** $g = \dfrac{GM}{r^2}$

$= \dfrac{(6.67 \times 10^{-11})(6.42 \times 10^{23})}{(3.39 \times 10^{6})^2}$ M1

$= 3.73 \text{ N kg}^{-1}$ A1

(ii) $\omega = \dfrac{2\pi}{T} = \dfrac{2\pi}{24.6 \times 60 \times 60}$ $(= 7.095 \times 10^{-5} \text{ rad s}^{-1})$

and $a = r\omega^2 = (3.39 \times 10^6)\left(\dfrac{2\pi}{24.6 \times 60 \times 60}\right)^2$ C1

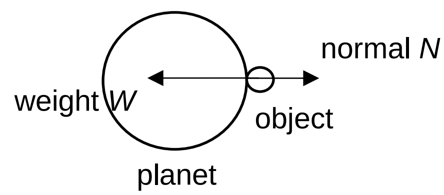
$= 0.0171 \text{ m s}^{-2}$ A1

(iii) Consider forces on the object,

$W - N$ = centripetal force C1

$N = W$ – centripetal force

$= m\,(3.73 - 0.0171)$



Force per unit mass $= N / m = 3.71 \text{ N kg}^{-1}$ A1

5 **(a)** It is the oscillatory motion of a particle whose acceleration is directly proportional to its displacement from a fixed point B1

and this acceleration is always in opposite direction to its displacement. B1

(b) $\omega^2 = \left(\dfrac{2k}{m}\right) = \dfrac{2(130)}{840 \times 10^{-3}}$ C1

$f = \dfrac{\omega}{2\pi} = \dfrac{1}{2\pi}\sqrt{\dfrac{2(130)}{840 \times 10^{-3}}}$ C1

$= 2.80 \text{ Hz}$ A1

(c) **(i)** resonance A1

(ii) The oscillator (continuously) supplies energy to the trolley. B1

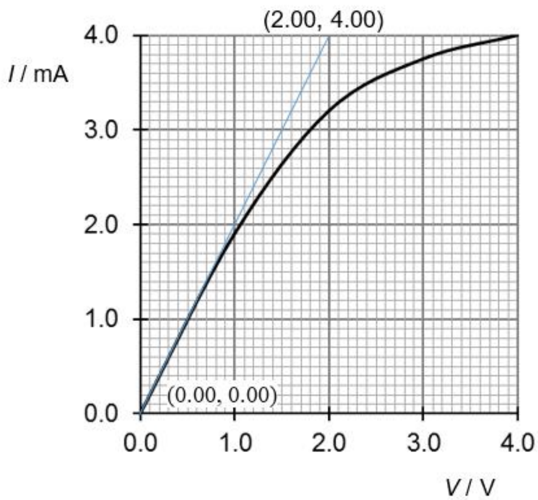
Since the amplitude of oscillation of the trolley is constant, the energy of trolley is constant, so energy must be dissipated due to resistive forces acting on the trolley. B1

or without loss of energy due to resistive forces acting on the trolley, the amplitude of oscillation of the trolley would continuously increase. B1

6 **(a)** The gradient of the **straight line** joining the origin and each point of the curve decreases with increasing potential difference. B1

Since **the gradient represents the reciprocal of the resistance of the filament lamp**, the resistance increases. B1

(b)



M1

The minimum resistance can be determined by drawing the tangent of the graph at the origin.

$$\text{gradient} = \frac{(4.00-0.00)\times10^{-3}}{2.00-0.00} = 2.00\times10^{-3}$$ C1

$$\text{Hence, resistance} = \frac{1}{2.00\times10^{-3}} = 500\ \Omega$$ A1

(c) From Fig. 6.1, when V = 4.00 V, I = 4.00 mA M1

$$\text{resistance of wire } R = \frac{4.00}{4.00\times10^{-3}} = 1000\ \Omega$$

$$\text{resistivity } \rho = \frac{RA}{L}$$

$$= \frac{(1000)\left(\frac{\pi}{4}\times(0.046\times10^{-3})^2\right)}{2.0}$$ C1

$$= 8.3\times10^{-7}\ \Omega\ \text{m}$$ A1

(d) From Fig. 6.1, when I = 1.00 mA,

V = 0.500 V = terminal p.d. across cell

$E - Ir = 0.500$

$E - (1/1000)(0.50) = 0.500$ C1

$E = 0.5005$ V A1

7 **(a)** The magnitude of velocity is not a constant B1

The acceleration is not always perpendicular to velocity B1

(b) **(i)** For the marble to be able to just complete the loop, N = 0 at the top. Hence, the weight of the marble provides the centripetal force.

$$mg = \frac{mv_{top}^{\ 2}}{r}$$

$$v_{top} = \sqrt{rg}$$

$$= \sqrt{0.183(9.81)}$$ C1

$$= 1.34 \text{ m s}^{-1}$$ A1

(ii) By conservation of energy,

$$mg(2r) + \frac{1}{2}mv_{top}^{\ 2} = \frac{1}{2}mv_{bottom}^{\ 2}$$ M1

$$2gr + \frac{1}{2}v_{top}^{\ 2} = \frac{1}{2}v_{bottom}^{\ 2}$$

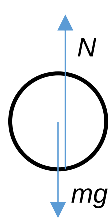
$$2(9.81)(0.183) + \frac{1}{2}(1.34^2) = \frac{1}{2}v_{bottom}^{\ 2}$$

$$v_{bottom} = \sqrt{2[2(9.81)(0.183) + \frac{1}{2}(1.34^2)]}$$ M1

$$= 2.996$$

$$= 3.00 \text{ m s}^{-1}$$ A0

(iii)



From the free body diagram,

$$N - mg = \frac{mv_{bottom}^{\ 2}}{r}$$

$$N = \frac{0.0200(3.00^2)}{0.183} + 0.0200(9.81)$$ C1

$$= 1.18 \text{ N}$$ A1

(iv)

$$KE_{bottom} = EPE$$

$$\frac{1}{2}mv_{bottom}{}^{2} = \frac{1}{2}kx^{2}$$ C1

$$x = \sqrt{\frac{mv_{bottom}{}^{2}}{k}}$$

$$= 0.0474 \text{ m}$$ A1

(c) (i) The principle of conservation of momentum states that the total momentum of a system of interacting bodies is constant provided no external resultant force acts on the system. B1

(ii) Inelastic A1

The relative speed of approach of 3.00 m s^{-1} s not equal to the relative speed of separation of 2.20 m s^{-1}. B1

Note: Must state values of RSA and RSS to be awarded 2nd mark.

(iii) By conservation of momentum,

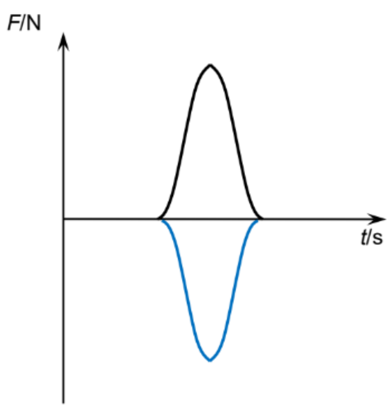
$$m_x u_x = m_x v_x + m_y v_y$$

$$0.0200(3.00) = 0.0200(-0.800) + m_y(1.40)$$ C1

$$m_y = \frac{0.0200(3.00+0.800)}{1.40}$$

$$= 0.0543 \text{ kg}$$ A1

(d) (i)



Graph should be symmetrical about horizontal time axis B1

(ii) The negative and positive areas represent the changes in momentum (or impulses) of the two marbles. B1

By Newton's Third Law, they are equal and opposite in direction, hence the total change in momentum for the two-marble system is zero. B1

Hence, total momentum of the system is constant,

(e) **(i)**

$$\begin{aligned}\text{Initial KE} &= \frac{1}{2}mv^2 \\ &= \frac{1}{2}(0.0543)(1.40^2) \\ &= 0.0532 \text{ J}\end{aligned}$$

A1

(ii)

$$\begin{aligned}\text{Work done against friction} &= \text{Loss in KE} \\ F \times d &= 0.0532 \\ F &= \frac{0.0532}{0.25} \\ &= 0.212 \text{ N}\end{aligned}$$

A1