JC2 Prelim (H2 Physics) Paper 1 Solutions

Qn	1	2	3	4	5	6	7	8	9	10
Ans	D	D	D	C	C	C	B	C	B	D

Qn	11	12	13	14	15	16	17	18	19	20
Ans	B	B	B	C	B	D	A	B	D	B

Qn	21	22	23	24	25	26	27	28	29	30
Ans	C	C	B	B	A	A	B	A	C	C

1 Ans: D

Depth of swimming pool ≈ 2m
Pressure at the bottom of the pool = $p_o + \rho gh$ = $\mathbf{10^5}$ + $(10^3)(10)2 = 10^5$ Pa

2 Ans: D

$[E] = \frac{|Q|^n}{|k|}$

$\text{kg m}^2\text{ s}^{-2} = \frac{A^n\text{ s}^n}{A^2\text{ s}^4\text{ kg}^{-1}\text{ m}^{-2}}$

$n = 2$

3 Ans: D

$d_2 - d_1 = 3.46$ mm
$\Delta(d_2 - d_1) = \Delta(d_2) + \Delta(d_1) = 0.03 + 0.02 = 0.05$ mm

$\frac{\Delta(d_2 - d_1)}{d_2 - d_1} \times 100\% = \frac{0.05}{3.46} \times 100\% = 1.4\%$

4 Ans: C

He decelerated in one direction and accelerated in the opposite direction at the same rate. Therefore the acceleration vector should be in the same direction before and after he made the U-turn.

5 Ans: C

Kinetic Energy = $p^2/2m$
Since both M and m have the same Kinetic Energy, $p^2 \propto m$

$\therefore \frac{p_M^2}{p_m^2} = \frac{M}{m}$

$\frac{p_M}{p_m} = \sqrt{\frac{M}{m}}$

6 Ans: C

F = Δp/Δt
5 = Δp/4
Δp = 20

7 Ans: B

Since the weight of the contents in the cup remains the same, no change to the pressure at the bottom.

8 Ans: C

Force constant, $k = \frac{5.0}{0.1} = 50\text{ N m}^{-1}$
Initial extension $= \frac{F}{k} = \frac{3}{50} = 0.06\text{ m}$ and final extension $= \frac{F}{k} = \frac{2.5}{50} = 0.05\text{ m}$
Change in E.P.E.$= \frac{1}{2}kx_f^2 - \frac{1}{2}kx_i^2 = \frac{1}{2}(50)(0.05)^2 - \frac{1}{2}(50)(0.06)^2 = -0.028\text{ J}$

9 Ans: B

Lorry is accelerated from rest to a speed of 100 km h^{-1} .
Work done by lorry's engine = increase in lorry's K.E.
Friction has to be ignored as minimum time is to be considered

$Pt = \frac{1}{2}mv^2$

$t = \frac{mv^2}{2P}$

where v = 100 km h^{-1} = 27.78 m s^{-1}

$\therefore t = \frac{(2000)27.78^2}{2 \times 50000} = 15.4$ s

10 Ans: D

Considering 10.0 g alone, T_2 provides the centripetal force for it.
$T_2 = m r \omega^2$
$= (0.010)(0.150 + 0.050)\ 6.28^2 = 0.079$ N

Considering 21.0 g alone, $(T_1 - T_2)$ provides the centripetal force for it.
$T_1 - T_2 = (0.021)(0.150)\ 6.28^2 = 0.124$ N
$T_1 = 0.203$ N
Ratio = 0.203 / 0.079 = 2.6

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11 Ans: B

$F_{net} = \frac{mv^2}{r} \Rightarrow mg - R = \frac{mv^2}{r}$

$R = mg - \frac{mv^2}{r}$

12 Ans: B

$\frac{GM_E/r_E^2}{GM_M/r_M^2} = 6$ ....(1) $\quad \frac{\rho_E}{\rho_M} = \frac{M_E/(4/3)\pi r_E^3}{M_M/(4/3)\pi r_M^3} = \frac{5}{3}$ ....(2)

From (1), $\frac{M_E}{M_M} = \frac{6r_E^2}{r_M^2}$ ....(3)

Substitute (3) into (2), $\frac{6r_E^2}{r_M^2} \times \frac{r_M^3}{r_E^3} = \frac{5}{3} \Rightarrow \frac{r_E}{r_M} = 3.6$

13 Ans: B

Given: **Actual** gas pressure = pressure **gauge reading** (of 200 kPa) + **atmospheric pressure** (of 100 kPa)
Thus initial actual gas pressure p_i = 200 + 100 kPa = 300 kPa, at initial temp of 25 ^{0}C
Assuming vol of tyre = const, actual gas pressure p ∝ T. Given $T_f = 50^0$C
→ Final actual gas pressure $p_f = (T_f/T_i) \times p_i$ = (50 +273.15)/(25 + 273.15) x 300 kPa
= 325 kPa
Thus final pressure **gauge** reading = 325 – 100 = 225 kPa
Thus $\Delta p/p_i$ in the pressure **gauge** readings = (225 – 200)/200 =0.125
In terms of percentage, = 0.125 x 100% = 12.5 %

14 Ans: C

Since heat supplied Q = ML + Heat loss to environment, M= mass vaporized/loss
Power supplied P = **m**L + h where m = **rate** of loss of mass of liquid,
h = **rate** of heat loss to environment
Substituting, $P_1 = m_1 L + h$ eqn (1), $P_2 = m_2 L + h$ eqn (2)
(1) – (2) gives $L = \frac{P_1 - P_2}{m_1 - m_2}$

15 Ans: B

ΔU = Q + W
= (+80) + (-100) = -20 J (B)

16 Ans: D

At point P, the displacement x is negative.
Since $a = -\omega^2 x \Rightarrow F = ma = -m\omega^2 x$.
A negative *x* will mean *F* is positive (B and C are eliminated as F is negative at these positions).
At point P, the velocity is negative.

Since a - t graph is a cosine graph, v - t graph will be a sine graph. Sketch this v-t graph on the same t axis as the given F-t graph. Can see that pt A has a positive velocity while pt D has a negative velocity. Hence ans is D.

17 Ans: A

For the object to remain in contact with the platform throughout the motion, its acceleration must not be greater than 9.81 m s^{-2}.

$a_{max} = \omega^2 x_0$

$x_0 = \frac{a_{max}}{\omega^2} = \frac{a_{max}}{(2\pi f)^2} = \frac{9.81}{(2\pi(1.5))^2} = 0.11\,\text{m}$

18 Ans: B

For a point source, intensity I ∝ 1/r^2 (1)
For all waves, intensity I ∝ (amp, A)^2 (2)
Thus, amplitude A ∝ 1/r
Substituting, 8X ∝ 1/r (A)
Final amplitude ∝ 1/(2r) (B)
(B)/(A): Final amplitude = 4X (B)

19 Ans: D

Given: λ = 600 nm. Deduce grating spacing d = 1/ (3.0 x 10^5) m
Total number of images = 2 $n_{highest}$ + 1 (1)
To det highest order of diffraction, $n_{highest}$:
From dsinθ = nλ, ⇒ $n_{highest}$ = dsin90/λ = 5.6
Since n must be an integer, $n_{highest}$ = 5 (the largest integer which is smaller than 5.6)
Thus in (1): total number of images = (2 x 5) + 1 = 11 (D)

20 Ans: B

From graph, when current is 40 mA, p.d. is approximately 1.2 V.

Therefore, p.d. across resistor = 6.0 – 1.2 = 4.8 V

R = V/I = (4.8)/(0.040) = 120 Ω

21 Ans: C

For 1 strand:
$R = \frac{\rho l}{A} = (1.72 \times 10^{-8}) \frac{1.0}{\pi\left(\frac{0.3 \times 10^{-3}}{2}\right)^2} = 0.2433\,\Omega$

For 7 strands in parallel:
$\frac{1}{R_{ll}} = \frac{1}{R} + \frac{1}{R} + \frac{1}{R} + \frac{1}{R} + \frac{1}{R} + \frac{1}{R} + \frac{1}{R}$

$R_{ll} = \frac{R}{7} = \frac{0.2433}{7} = 0.03476\,\Omega$

$V = IR_{ll} = (13)(0.03476) = 0.4519\,V$

22 Ans: C

When switch is open:

$V = E - Ir$

$1.5 = E - (0)r$

$E = 1.5$ V

When switch is closed:
$V = E - Ir$

$0.75 = 1.5 - (0.75/4.0)r$

$r = 4.0\ \Omega$

23 And: B

Direction of E-field = direction of force acting on a **positive** charge placed at that position. This is taken to be a tangent if the field line is a curve.

Thus force acts on the electron (a negative charge) in the opposite direction along the tangent drawn at X.

24 Ans: B

The centripetal force on the particle when entering is upwards hence magnetic force is upwards.
Using Fleming's left hand rule, current is in the same direction as the velocity of the particle, so it must be positively charged.
If direction of magnetic force is upwards, electric force on that positive charged particle must be downwards so electric field must also be downwards.

25 Ans: A

There is no change of flux linkage

26 Ans: A

$$I = I_0 \sin \omega t = \sqrt{\frac{P_0}{R}} \sin \frac{2\pi}{T} t = \sqrt{\frac{150}{6.0}} \sin \frac{2\pi}{0.020} t$$
$$I = 5.0 \sin 100\pi t$$

27 Ans: B

The highest energy level the hydrogen atom can reach is n = 3 if max KE is 12.5 eV.
The following transitions and the corresponding wavelengths are:
$\lambda = hc/E = [(6.63 \times 10^{-34})(3.00 \times 10^{8})/(1.60 \times 10^{-19})]/\Delta E$ in eV

n = 3 to n = 2: $\lambda = 1.24 \times 10^{-6} /(3.40 - 1.53) = 6.65 \times 10^{-7}$ m (red)
n = 3 to n = 1: $\lambda = 1.24 \times 10^{-6} /(13.6 - 1.53) = 1.03 \times 10^{-7}$ m (not visible, outside 400nm to 700nm)
n = 2 to n = 1: $\lambda = 1.24 \times 10^{-6} /(13.6 - 3.40) = 1.22 \times 10^{-7}$ m (not visible, outside 400nm to 700nm)

28 Ans: A

$h\,c / \lambda_{min} = e\,V_a$

Since the accelerating voltage has increased, the minimum wavelength will decrease.

29 Ans: C

$\Delta m\, c^2$ = Energy of photon emitted
$(m_{excited} - 59.9308\ u)\, c^2 = 2.13 \times 10^{-13}$ J
$(m_{excited} - 59.9308\ u) = 2.366667 \times 10^{-30}$ **kg**
Since 1 u = 1.66 x 10^{-27} kg, $(m_{excited} - 59.9308\ u) = 0.0014257$ **u**
$m_{excited} = 59.9322$ u (C)

30 Ans: C

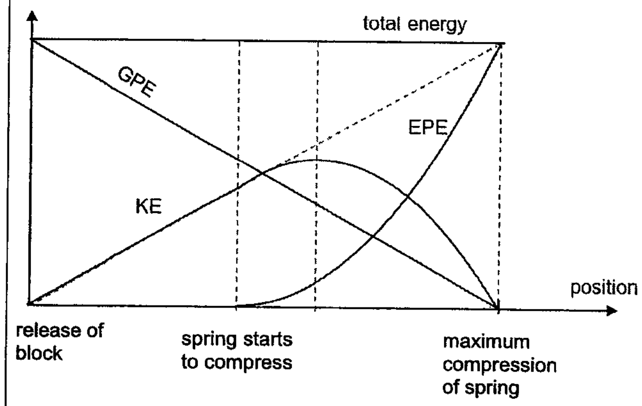
Given half-life = 60 days & tin-124 is stable.
After one half-life: $N_{Ant} : N_{Tin} = 1:1$
After 2 half-lives:
$N_{Ant} : N_{Tin} = 1:3$ since N_{Ant} = ¼ Initial number of Antimony &
N_{Tin} = ¾ of Initial number of Antimony
After 3 half-lives: $N_{Ant} : N_{Tin} = 1:7$ since $N_{Ant} = \frac{1}{8}$ Initial number of Antimony
$N_{Tin} = \frac{7}{8}$ of Initial number of Antimony
Thus $\frac{number\ of\ tin-124\ nuclei}{number\ of\ antimony-124\ nuclei} = 6$ occurs betw 2 & 3 half-lives,
ie betw 120 & 180 days. (C)
Alternatively, we can calculate the actual number of days as shown:
Since Tin is **stable,** $N_{Ant} + N_{Tin}$ = initial number of Antimony, N_o
After time t: $N_{tin} = 6\ N_{Ant}$, we can deduce $\frac{N_{Ant}}{N_o} = \frac{1}{7}$
Substitute into eqn $N = N_o\, e^{-\lambda t}$ for Antimony, t = 168 days.

BP~453

JC2 Prelim (H2 Physics) Paper 2 Solutions

1 (a)(i)	{Given: m = 0.3 kg; k = 80 N m^{-1}; obeys Hooke's law} At point of release: v = 0, KE = 0. Let GPE = 0 at the point of release. At point of **max compression**: v = 0,→ KE = 0 **Loss in GPE = Gain in elastic potential energy { + zero KE }** $mg(0.10+x_{max})=\frac{1}{2}kx_{max}^{2}$ (A)	[1]
	$0.30(9.81)(0.10+x_{max})=\frac{1}{2}(80)x_{max}^{2}$ → Max compression $x_{max}=0.13$ m	[1]
(ii)1.	{As compression (ie x) increases, **upward** force exerted by spring increases **until it becomes = mg (downward);** hence, block **accelerates at a decreasing rate while increasing in speed**, as spring is being compressed under a **net force = mg - kx.** Hence kinetic energy increases **until F_{net} = 0**, (reaches a **max**) ie compression continues until (mg - kx) becomes 0.} At max ke: $mg=kx$ (A) {Explanation: since **F_{net} = 0}** ie 0.30 (9.81) = 80 x $x=\frac{mg}{k}=\frac{0.30(9.81)}{80}$ = 0.037 m (shown)	[1]
2.	Loss in GPE = mg (0.10 **+ 0.037)**	[1]
	Loss in GPE = Gain in EPE + Gain in KE {using energy considerations} **mg(0.10 + 0.037) = $\frac{1}{2}$k(0.037)^2+ Gain in KE** → Gain in KE = Loss in GPE – EPE = (0.30)(9.81)(0.10+0.037) – $\frac{1}{2}$(80)(0.037)^2 = 0.403 – 0.0547 = 0.35 J	[1 - ecf]
	⇒ Maximum KE = 0.35 J (initial KE = 0 J)	[1 -ecf]

(iii)



[3]
{[1] for each correct graph}

2(a)(i)	• Satellite lies on equatorial <u>plane</u> of the Earth. • Rotates fr west to east.	[1] [1]
(a)(ii)	Any 1: • <u>no tracking of the satellite required to receive signals from Earth</u> • Since it's positioned at high altitude, it has a <u>large spatial coverage</u> • <u>can monitor the same area consistently</u> { ie can send & receive transmission from the area under observation without interruption}	[1]
(b)(i)	{Given: ϕ = potential at the surface of sphere of radius r. *Required: the potential fr d = r to d = 4r. For d < r: not required}* curve from r to 4r, with gradient of decreasing magnitude and starting at (r, ± ϕ), passing through (2r, ± **0.5ϕ**) and (4r, ± **0.25ϕ)** **according to** $\phi=-\frac{GM}{r}$.	[1]
	line (this must be a curve) showing potential is **negative throughout.**	[1]
(ii)	GPE = - GMm/r change = GPE_{final} - $GPE_{initial}$ $=-\frac{6.67\times10^{-11}(6.0\times10^{24})(3.4\times10^{3})}{(6.4\times10^{6})}(\frac{1}{4}-\frac{1}{3})$	[1]
	= - 1.77 × 10^{10} J = - 1.8 × 10^{10} J	[1]

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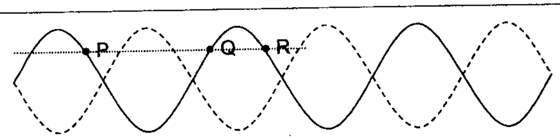
(iii)	rock loses GPE, (so) KE increases {by PCE} or GPE converted to KE or since the net force is the attractive gravitational force, there is an acceleration so speed increases.	[1] [1]
3(a)(i)	Two waves are coherent if they have a **constant phase difference** {not zero phase difference} between them.	[1]
(ii)	estimated range of λ (for red light) = 700 nm (650 – 750 nm) Fringe separation $x = \frac{\lambda D}{a}$ where D = 2.4 m; a = 0.86 mm = 8.6 x 10^{-4} m For λ = 700 x 10^{-9} m, x = 1.95 mm {required unit in mm} For 650 nm: x = 1.81 mm; for 750 nm, x = 2.09 mm	[1] [1-ecf] [1-ecf]
(iii)	Dark fringes become **less dark, or, become brighter, or intensity increases.** {Accept: **no longer *completely* dark**} The **amplitudes** of the 2 waves that superpose at a dark fringe are **no longer equal**. (By the Principle of Superposition), the **resultant amplitude** (& hence, intensity), will **no longer be zero**, or , **completely destructive interference** no longer occurs.	[1] [1] [1]
(b)(i)	c = fλ, { where c = 3.00 x 10^8 m s^{-1} , f = 2.45 **GHz** = 2.45 x 10^9 Hz } → λ = 0.122 m	[1] [1]
(ii)	 All 3 pts correct: award [2] ; 2 pts correct: [1]	[2]
4 (a)(i)	I = V/R = (1.5)/(8.0) = 0.188 A = 0.19 A F = BILsin90° = (1.2×10^{-2})(0.188)(24) = 0.054 N	[1] [1]
(a)(ii)	Resistance of wire increases by a factor of 4 (since R∝ $1/A$, $A \propto d^2$) or, current decreases by a factor of 4 Hence, force decreases by a factor of 4 (since F ∝ I)	[1] [1]

(b)(i)	F upwards *between the poles* (perpendicular to wire)	[1]
(b)(ii)	Deduce Period T = 20 ms = 20 x 10^{-3} s (fr Fig 4.3) → f = 1/T = 1/(20×10^{-3}) = 50 Hz **λ/2 = 0.75 m** (for **fundamental** frequency) → λ = 1.50 m v = f λ = (50)(1.50) = 75 m s^{-1}	[1] [1 – ecf]
(b)(iii)	A **stationary wave** (is formed on the wire between the clamps). {Drawing a diagram with a **single loop** betw the 2 clamps will be most helpful.} **Amplitude varies at every point.** {By drawing, show that the amplitudes at 2 different positions are different. No credit if discussion is on **nodes** and antinodes only because "all points on the wire "BETWEEN THE CLAMPS" means the **nodes are to be excluded from discussion.**} Since **a = - ω²x,** (maximum) **acceleration is proportional to amplitude**; hence acceleration is different for different pts on the wire.	[1] [1] [1]
5(a)(i)	AC voltages can be **stepped up and stepped down using a transformer** for a more efficient transmission of power. {This is an advantage because with DC voltages, stepping them up & down is more difficult to achieve.}	[1]
(a)(ii)	For a **given amount of power generated**, electrical energy transmitted at high voltages would mean a **lower current** in the cables { P_{gen} = IV}, & thus, **less power loss** in cables, or **reduced heating** in cables, (or thinner cables can be used, leading to reduced cost).	[1] [1]
(b)(i)	Lamination **reduces** {not: prevents} **power loss in the core** due to **eddy currents.** {Accept "induced current"}	[1] [1]
(b)(ii)	**no power loss** in *transformer* (but not power loss in the wires or power loss in the core) or, **input power (to the primary) = output power (of the secondary)**	[1]
(c)	{ Given: N_P = 300, N_S = 8100 $V_{rms,\,primary}$ = 9.0 V } $\frac{V_s}{V_p} = \frac{N_s}{N_p}$ $\frac{V_s}{9.0} = \frac{8100}{300}$ → $V_{rms,sec}$ = 243 V → peak $V_s = \sqrt{2} \times 243$ = 344 V = 340 V	 [1]

6 (a)(i)	Q = It →Ne = It $\frac{N}{t} = \frac{I}{e}$ { I = 4.2 x 10^{-9} A from Fig 6.2 at V = 2.0 V} $= \frac{4.2 \times 10^{-9}}{1.6 \times 10^{-19}}$ = 2.63×10^{10} s^{-1}	[1] [1]
(a)(ii)1.	No change (Max energy is a function of freq & ϕ since $hf = \phi + \frac{1}{2} m_e v^2_{max}$)	[1]
(a)(ii)2.	{From line 1 p 14, candidates need to deduce the frequency is kept const as the intensity is increased} Increasing the intensity increases the rate (of incidence) of the photons, $\frac{n}{t}$. Hence the photoelectric current increases since current increases when rate of emission of electrons increases.	[1] [1]
(b)(i)	The minimum energy required to eject an electron (from a metal surface).	[1]
(b)(ii)	Since **work function energy $\phi \propto f_0$, or $\phi = hf_0$**, where f_0 is the threshold frequency, potassium has the lowest threshold frequency as **potassium has the lowest work function energy**.	[2]
(iii)	$hf = \phi + KE_{max}$ $h\frac{c}{\lambda} = \phi + KE_{max}$ $\left(\frac{6.63\times10^{-34}\times3\times10^{8}}{3.2\times10^{-7}}\right) = 3.7\times(1.6\times10^{-19}) + KE_{max}$ $KE_{max} = 2.96 \times 10^{-20}$ J	[1] [1]
(iv)	KE = ½ $m_e v^2$ 2.96 × 10^{-20} = ½ (9.11×10^{-31}) v^2 → v = 2.549×10^5 m s^{-1} $\lambda = \frac{h}{mv} = \frac{6.63\times10^{-34}}{9.11\times10^{-31}\times2.549\times10^{5}}$ = 2.86 × 10^{-9} m	[1 -ecf] [1 -ecf]

7(a)(i)	Nuclear fusion	[1]
(ii)	**Origin of the energy source**: 1. rotation (energy) of Earth 2. **gravitational forces** produced by the Moon and/or Sun **on the water**{see para 2 line 2 &3}	[1] [1]
(b)(i)	from GPE to electrical (ignore intermediate kinetic energy) or **rotational** KE (of Earth) to electrical (ignore intermediate kinetic energy)	[1]
(ii)	Any two of: friction between water and pipe, viscosity within water, friction between moving parts, resistive heating in coils, cables eddy currents in transformer / generator	[2]
(c)(i)	Rate of loss of GPE = mgΔh/ t = ρ(V/t)gΔh = 1.03 × 10^3 × 2100 × 9.81 × **12.4** = 2.63 × 10^8 J s^{-1}	[1] [1-ecf for incorrect Δh]
(ii)	Output power, P = (90.5/100) × 2.63 × 10^8 = 2.38 x 10^8 W = 238 MW	[1-ecf]
(iii)	P = IV where V = 225 kV I = P/V = 2.38 × 10^8 / 225 x 10^3 = 1.06 × 10^3 A	[1-ecf] [1]
(d)(i)	(Given: **annual** energy output = 5.4 x 10^8 **kWh**) = 5.4 x 10^8 x 10^3 x 3600 J C_F = actual energy generated / theoretical max electrical energy output Theoretical maximum electrical energy output from generators per annum = 240 x 10^6 × 365 x 24 Wh (para 2 line 3) {NOT: 238 x 10^6} = 2.1 x 10^{12} Wh , or 2.10 x 10^6 MWh or **2 x 10^9 kWh** C_F = 5.4 x 10^8 (kWh) / 2 x 10^9 (kWh) = 0 .257 or 25.7 %	[1] [1 - ecf for (c)(ii) value e.g 238 MW] [1 – ecf for (c)(ii) value e.g 238 MW]
(ii)	Any one of: (there are times when) generation is less than the maximum level due to energy loss , or, when water levels are not sufficiently different or water levels are equal	[1]

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(e)(i)1.	$F_M = 2GMmR / r^3$ $= 2 \times (6.67 \times 10^{-11}) \times (7.35 \times 10^{22}) \times (1.00) \times (6.38 \times 10^6) \div (3.84 \times 10^8)^3$ $= 1.10 \times 10^{-6}$ N	[1] [1]
2.	$F_M / F_S = (M_M/r_{earth\ orbit}{}^3) \div (M_S/r_{moon\ orbit}{}^3)$ $= 7.35 \times 10^{22} \times (1.50 \times 10^{11})^3 \div (1.99 \times 10^{30} \times (3.84 \times 10^8)^3)$ $= 2.20$ The effect of the Moon on the tides is more significant/2.2 times more than the effect of the Sun	[1] [1] [1-ecf based on what their ans]
(ii)	Earth, Moon Sun line up/in straight line, (last para lines 2 & 3) (lunar and solar) tides/ tidal forces reinforce each other.	[1] [1]

End of solutions

JC2 Prelim (H2 Physics) Paper 3 Solution & Post Mortem

1 (a)(i)	For a body to be in rotational equilibrium, the sum of all the anticlockwise moments ***about any point*** must be equal to the sum of all the clockwise moments about that **same point.**	[1]
(a)(ii)	{Given: wt of beam = 17.5 N; wt of object = 26.5 N} Taking moments about wooden block 1, B x 800 = 26.5 x 200 + 17.5 x 400 B = 15.4 N	[1] [1]
(a)(iii)	Sum of forces A & B = 44 N Since the beam is in (translational) equilibrium, the total force acting downward (26.5 + 17.5 N) is equal to the total force acting upward (ie A + B).	[1] [1]
(a)(iv)	Any 2 1. A becomes less and B becomes greater 2. The sum of A and B is constant (= 44 N) 3. Same amount of increase and decrease for A and B. 4. At centre A = B	[2]
(b)	Vertically: $T_1\sin50^0 + T_2\sin40^0 = 392$ N $0.7660T_1 + 0.6428T_2 = 392$ -------- (1) Horizontally: $T_1\cos50^0 = T_2\cos40^0$ $0.6428T_1 = 0.7660T_2$ $T_1 = 1.192T_2$ ------------(2) Sub (2) in (1): $0.7660(1.192T_2) + 0.6428T_2 = 392$ $1.556T_2 = 392$ $T_2 = 251.9$ N = 252 N Sub in (2): $T_1 = 1.192(251.9)$ = 300.3 N = 300 N Alternatively, may use the vector triangle.	[1] [1]

2(a)(i)	Both gases are at the <u>same temperature</u> or No <u>net</u> flow/transfer of heat between the 2 gases	[1]
(ii)	Since $pV = \frac{1}{3}Nm\langle c^2\rangle$, $\frac{1}{2}Nm\langle c^2\rangle = (3/2)pV$ Since pV = NkT, { ideal gas eqn} $\frac{1}{2}Nm\langle c^2\rangle = (3/2)NkT$ mean KE of a molecule = $\frac{1}{2}m\langle c^2\rangle$ {NOT: $\frac{1}{2}mv^2$} = (3/2) kT	[1] [1]
(iii)	{Given: Before mixing, T of hydrogen = 420 K} mean KE of a molecule = $\frac{1}{2}m\langle c^2\rangle = (3/2)kT$ $= (3/2)(1.38 \times 10^{-23})(420)$ $= 8.69 \times 10^{-21}$ J	[1]
(b)(i)	Gases at *same temp* would have <u>same</u> (mean) <u>KE,</u> or same $\frac{1}{2}m\langle c^2\rangle$ {since $\frac{1}{2}m\langle c^2\rangle = (3/2)kT$ }. Since the <u>mass of a molecule/molecular mass</u> for the 2 gases is <u>different</u>, the mean square speed must be different (so that $\frac{1}{2}m\langle c^2\rangle$ of the 2 can be the same.)	[1] [1]
(b)(ii)	{<u>Deduce</u> that both the hydrogen and oxygen molecules are <u>at the same temp</u> & hence the 2 gases have the same $\frac{1}{2}m\langle c^2\rangle$.} Since <u>a hydrogen **molecule** has a smaller mass than an oxygen</u> <u>**molecule**, rms speed of H_2 > rms speed for O_2</u> .(Accept "mean square speed") Thus, when compared with O_2, molecules of H_2 have a <u>**higher probability/proportion of molecules**</u> of exceeding **the <u>escape speed</u>** of Earth. {Hence more H_2 than O_2 molecules are expected to leave earth's atmosphere.}	[1] [1]

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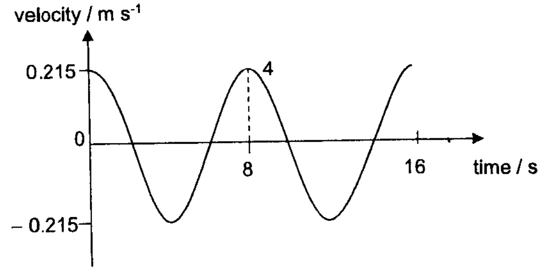
3 (a)(i)	{Given: $a = -\frac{16}{m}x$} Since 16/m is a constant, acceleration ∝ to its displacement from its equilibrium position. Furthermore acceleration is always directed towards that position as indicated by the negative sign. Thus the block is performing shm as it satisfies the 2 defining conditions of shm.	[1] [1] [1]
(a)(ii) 1	From graph, deduce period of shm T = 8 s { NOT: 4 s} $f = \frac{1}{T} = \frac{1}{8} = 0.125$ Hz	[1]
(a)(ii) 2	Comparing $a = -\omega^2 x$ with $a = -\frac{16}{m}x$, $\Rightarrow 4\pi^2 f^2 = \frac{16}{m}$ $\rightarrow m$ = 25.9 kg	[1] [1-ecf]
(a)(ii)3	Max. p.e. $= \frac{1}{2}m\omega^2 x_o^2 = 0.600$ J (fr graph) (deduce $m\omega^2 = 16$) $\rightarrow x_o = 0.274$ m	[1] [1]
(a)(ii) 4	Z lies **between 0 and 1 s** (at 0.67 s) or **between 3 and 4 s** (at 3.3 s)	[1]
(b)	 $v_{max} = \omega x_0 = 2\pi(0.125 \text{ fr (ii)}) \times (0.274 \text{ fr (ii)})$ $= 0.215$ m s^{-1}	[1, shape: cosine or -cosine graph] [1, magnitude of v_{max} and period, allow ecf]

4(a)(i)	From $v = f\lambda$, $\lambda = \frac{330}{5000} = 0.066\,m$ Phase difference, $\phi = \frac{x}{\lambda} \times 2\pi = \frac{0.033}{0.066} \times 2\pi = \pi$ rad $\Rightarrow$ molecules are in anti-phase.	[1] [1] [1 ecf]
(a)(ii)	Energy received $= Power_{received}\ x\ time$ $= (I_{received} \times A_{ear})\,t$ $= (3.0 \times 10^{-2}) \times (5.5 \times 10^{-5}) \times 15$ $= 2.48 \times 10^{-5}$ J	[1] [1]
(a)(iii)	(The plane of) the eardrum is perpendicular to direction of the waves	[1]
(b)	The wave particles **oscillate/vibrate** (not: move, travel) in **one direction in a plane normal to the direction of energy transfer** The oscillations of an unpolarized wave can be in any direction (ie not restricted to only one direction).	[1] [1]

5 (a)(i)	$P = \frac{V^2}{R}$ (where P_{max} = 4.5 W, R = 2 Ω) $4.5 = \frac{V^2}{2.0}$ V= 3.0 V Alternatively, P = I²R 4.5 = I² (2.0) I = 1.5 A V = IR = (1.5)(2.0) = 3.0 V)	[1] [1]
(a)(ii)	The supply has internal resistance. Hence the answer in (i) + p.d. across the internal resistance = e.m.f	[1]
(b)(i)	Q = It Ne = It N(1.6 × 10^{-19}) = (0.48 A)(150 s) N = 4.5 × 10^{20}	[1]
(b)(ii)	Given 18 Ω and 36 Ω in parallel: $\frac{1}{18} + \frac{1}{36} = \frac{1}{R_{ll}}$ R_{ll} = 12 Ω Total resistance of circuit = 12Ω + 12Ω = 24 Ω E = IR = (0.48)(24) = 11.52 V (OR V_{12} = 0.48×12 = 5.76 V V_{18} = 0.32×18 = 5.76 V (or V_{36} = 0.16×36 = 5.76 V) [1] E = V_{12} + V_{18} = 11.52 V [1])	[1] [1]

6(a)	Induced e.m.f. in a coil is proportional to the rate of change of magnetic flux (linkage) of the coil.	[1]
(b)(i)	Flux linkage = NBA (radius of coil = 1.6 x10^{-2} m) = 85 x (πx 10^{-3} x 2.8)x (π x (1.6 x 10^{-2})^2) = 6.00 x 10^{-4} Wb	[1]
(b)(ii)	Flux linkage change = (6.00 x 10^{-4}) – (– 6.00 x 10^{-4}) Wb = 2x 6.00 x 10^{-4} Wb = 12.00 x 10^{-4} Wb Mean emf = d(flux linkage)/t where t = 0.30 s = (12.00 x 10^{-4} Wb) ÷ (0.30 s) = 0.004 V = 4 mV	[1-ecf] [1-ecf]
(b) (iii)	**0 V** from t = 0 to 0.3 s, t = 0.6 to 1.0 s and t > 1.6 s (because when <u>current is const</u> & B = constant, thus <u>flux linkage is const</u>; hence induced emf = zero, in accordance to Faraday's Law. This must be drawn CLEARLY in the graph) <u>From t = 0.3 to 0.6 s</u>, the current changes as shown in (b) (ii). Hence induced emf = **4 mV** (Let a positive sign be given to this emf) <u>From t = 1.0 to 1.6 s</u>: the <u>current changes</u> by the <u>same amount</u> as betw 0.3 to 0.6 s, but the <u>time taken is doubled</u>. Hence the magnitude of the induced emf is **half** that in (b)(ii), ie 2 mV. Since the change in current is <u>from low to high</u> current- opposite to that betw 0.3 to 0.6 s, the <u>induced emf</u> here is opposite in sign to that between 0.3 to 0.6 s, ie **– 2 mV.**	[1] [1] [1]
7(a) (i)	The process <u>cannot be controlled (or affected) by external factors</u> – factors outside (external to) the nucleus, like <u>pressure, temperature</u>. {at least one factor cited}	[1]
(a)(ii)	It is impossible to know <u>when</u> the next disintegration/decay will occur. The **<u>probability of decay per unit time</u>** of a nucleus is <u>constant</u>. {This answer, "cannot predict <u>which</u> particular nucleus will decay next" is not acceptable.}	[1] [1]
(b)(i)	${}_{2}^{3}He + {}_{2}^{3}He \rightarrow {}_{2}^{4}He + 2\,{}_{1}^{1}p$ + 13.8 MeV	[1]
(b)(ii)1.	gamma ray/radiation/photon {Accept: γ-ray, Symbol γ must be clear. It should not look like 'Y'}	[1]
2.	13.8 MeV is the (total) energy released, which = **sum** of the **<u>ke of the products</u>** (${}_{2}^{4}He$ & the 2 protons) **and the energy of the radiation.**	[1]

(b) (iii)	{Let $\frac{N}{t}$ be the required minimum number of reactions per second. Since each reaction produces 13.8 MeV, where 1 MeV = 10^6 x 1.6 x 10^{-19} J} $\frac{N}{t}$ x 13.8 x (10^6 x 1.6 x 10^{-19} J) = 60 W → $\frac{N}{t}$ = 2.72 x 10^{13} s^{-1}	[1] [1]
(c)	Energy released = Tot Binding energy of Products – Tot BE of reactants = (4x 7.20) + 0 (for ${}_{0}^{1}n$) – (2 x 1.11) – (3 x 2.66) = 18.6 MeV	[2] [1]
	<u>Section B</u>	
8(a)(i)	800 sin 50° = 613 m s^{-1} = 6.13 x 10^2 m s^{-1}	[1]
(a)(ii)	$s_y = u_y t + ½ a t^2$ 0 = 800 sin 50° (t) + ½ (-9.81) (t^2) t = 125 s {total time of flight} Range = s_x = u_x t =(800 cos 50°)x (125) = (514 m s^{-1}) x (125 s) = 64.2 x 10^3 m = 64.2 km [ecf allowed]	[1] [1] [1]
(a)(iii)	**Time of flight is shorter** { & so the enemy tank has less time to react. {Range = ucosθ x Time of flight}; NOT because the initial vert velocity is smaller}	[1]
(b)(i)	<u>To find horiz displacement when accelerating at 1 m s^{-2} to its max speed</u> of 60 km km h^{-1} (ie to 16.7 m s^{-1}): $v^2 = u^2 + 2as$ (60000 / 3600)^2 = 0 + 2(1)(s) s_x = 138.89m <u>To find time required to reach max speed from rest at max acc of 1 m s^{-2}</u>: $s = ut_1 + ½ a t_1^2$ 138.89 = 0 + ½ (1)(t_1)^2 t_1 = 16.67 s <u>To find time taken to travel remaining distance at max speed</u>: (Initial dist apart = 3000 m) $S_x = ut_2$ 3000 – 138.89 = (60000 / 3600)(t_2) t_2 = 171.67 s Thus minimum time required = $t_1 + t_2$ = 171.67 + 16.67 = 188.3 s	[1] [1] [1] [1]

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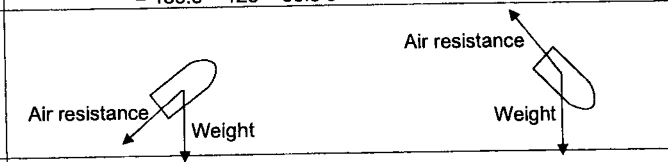
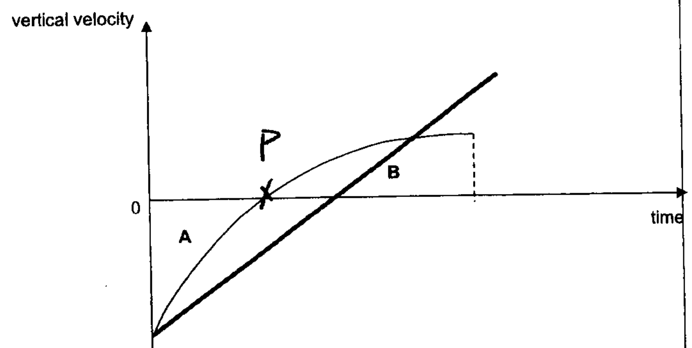
	Alternatively, To find time required to reach maximum speed, $v = u + at_1$ $60000 / 3600 = 0 + (1)(t_1)$ $t_1 = 16.67$ s To find the distance travelled while accelerating to max speed, $s = ut + ½ at^2$ $= 0 + ½ (1)(16.67)^2$ $= 138.89$ m To find the time taken to travel remaining distance at top speed: (Initial separation = 3 km) $s = ut_2$ $3000 – 138.89 = (60000 / 3600)(t_2)$ $t_2 = 171.67$ s Minimum time required = $t_1 + t_2$ = 171.67 + 16.67 = 188.3 s	[1] [1] [1] [1]
(b)(ii)	time required = (bi) – Time of flight in (aii) = 188.3 – 125 = 63.3 s	[1-ecf]
(c)(i)	 	[2]
(c)(ii)	 Correct shape with x-intercept before the x-intercept of the original graph Initial speed > final speed **Equal area before and after reach max height** (A = B)	 [1] [1] [1]
(c)(iii)	P is the instant **when air resistance = 0**, hence, at where vertical velocity = 0 [Refer to the diagram in (c)(ii)]	[1]

(d)(i)	For a system of interacting bodies, the total momentum of the bodies (i.e. momentum of the system) remains constant, provided no net force acts on the system.	[1] [1]
(d)(ii)	It cannot be applied as there is an (horizontal) external force acting on the system. The external force can be: the ground exerting a contact force/friction on the howitzer, or weight of projectile, or air resistance on projectile.	[1] [1]
9(a)(i)	Electric field strength is the **force per unit positive charge**.	[1] [1]
(ii)1.	A (since the positive charge accelerates from A towards B)	[1]
2.	{ Given: initial speed = 0; KE at plate B = 2.4×10^{-16} J } Work done by field = KE gain by charge = 2.4×10^{-16} J.	[1]
3.	W = Fs { since F = const} F = W/s { distance betw plates, s = 15 mm = 0.015 m} $F = 2.4 \times 10^{-16} / 15 \times 10^{-3} = 1.6 \times 10^{-14}$ N or alternative method: KE = 1/2mv² $v^2 = u^2 + 2as$ F = ma	[1-ecf] [1-ecf]
4.	$V = E/d = Fd / Q$ or $V = W / Q$ or $E = V / d$ and $E = F / Q$ *Pd* $V = (1.6 \times 10^{-14} \times 15 \times 10^{-3}) / 1.6 \times 10^{-19}$ or $2.4 \times 10^{-16} / 1.6 \times 10^{-19}$ = 1500 V	[1-ecf] [1-ecf] [1-ecf]
(iii)	straight line with positive gradient starting at origin and ending at x =15 mm.	[1]
(iv)	It will decelerate/slow down and stop before reaching B and accelerate/move to A after a momentary stop	[1] [1]
(b)(i)	Charge must be moving (ie not stationary), with a velocity that is not parallel to the magnetic field.	[1] [1]
(ii)	The speed is decreasing (due to collision with the particles of the medium). This causes the radius to decrease.	[1] [1]
(iii)1.	Since the spirals are in opposite directions, the charges must be oppositely charged.	[1] [1]

2.	Equal **initial** radius,	[1]
	so equal initial speeds.	[1]

End of solutions

Mark Scheme of Q1 of Prelim Pract 2022 (Centre of gravity of card: 2021 Q1)

	Marking Point	Mark	Score
	□ Recorded **at least 2 values** and **average** of *b* & *c* to **nearest mm** □ Accuracy: **11.5 cm ≤ b ≥ 12.5 cm ; 15.5 cm ≤ c ≥ 16.5 cm**	1	
	□ Recorded **at least 2 values** and **average** of *y* to **nearest mm** □ Accuracy: **4.6 cm ≤ y ≥ 5.0 cm**	1 1	
(c)(i)	□ Recorded **at least 2 values** and **average** of *c* to **nearest mm** □ Accuracy: **9.5 cm ≤ c ≥ 10.5 cm**	1	
(c)(ii)	□ Recorded **at least 2 values** and **average** of *y* to **nearest mm** □ **5.0 cm ≤ y ≥ 5.5 cm**	1	
(d)(i)	Calculated Quantities: □ Accuracy of Calculation **5.2 cm ≤ y ≥ 6.0 cm** {value of b = 12.0 cm, c = 4.0 cm} □ **Number of sf in *y*: 2 or 3 sf** { must be same or one more than the least sf among *b* and *c* }	1	
(d)(ii)	Linerisation of equation □ Plot $y(b + c/2)$ vs c, (A) or, y vs $\frac{\frac{b^2}{2}+\frac{bc}{8}}{b+\frac{c}{2}}$, (B) or, y vs (4b+c)/(2b+c), (C) etc Thus, in (A), $Y = y(b + c/2)$ & X = c; In (B), Y = y & $X = \frac{\frac{b^2}{2}+\frac{bc}{8}}{b+\frac{c}{2}}$; while in (C), Y = y & X = (4b+c)/(2b+c)	1	
(d)(iii)	Determination of Gradient and y-intercept {No ECF} □ State: gradient = *b*/8 & y-intercept = $b^2/2$, for (A) or, gradient = 1 & y-intercept = 0 for (B) or, gradient = b/4 & y-intercept = 0 for (C) { Units for gradient & intercept: not assessed }	1 (grad) 1 (intercept)	

(iv)	Why y = 6 cm when c = 0 (without calculation): □ State: shape of cardboard becomes a **square.** □ State: centre of gravity of a square is at its geometrical centre (hence y = b/2 = 6 cm)	1 1	
	Total	11	

Mark Scheme of Q2 of Prelim Pract 2022 (Changing Resistances in a circuit: 2021 Q2)

	Marking Point	Mark	Score
	□ Recorded value of R_Y as provided, ie **10 Ω**	nil	
	□ Recorded value of I_1 to **one dp in mA** (or 4 dp in A).	nil	
	□ Recorded value of I_2 to **one dp in mA** (or 4 dp in A) in (a) and in (b)	1	
(b)	Minimum Sets of Raw Data Tabulated □ Collected **6 sets** of raw data (ie of R_Y, I_1 & I_2) without help. Deduct 1 m if student requires assistance.	1	
	Column Headings & Tabulation & Correct Precision for R_Y & I_1 & I_2 □ Each **column heading** (of R_Y, I_1, I_2 and I_1/I_2) contains a quantity and a unit. I_1/I_2 has no unit. ECF for wrong unit of I_2. □ **First set** of readings taken in (a) is recorded in this table. □ R_Y recorded as labelled ie to **nearest ohm** & I_1 & I_2 to **1 dp in mA**	1	
	Calculated Quantities: □ Precision & Consistency of Recording **All** values of I_1/I_2 recorded to **same no. of s.f. or one more, consistently** as their corresponding raw data (I_1 & I_2). *Thus* I_1/I_2 **are recorded to 3 sf for all values, or to 4 sf for all values.** □ Accuracy of Calculation **All** values of I_1/I_2 correctly calculated.	1	
	Penalty for a Constant value for either I_1 & I_2: *deduct 3 marks:* *2 m from (b) Minimum Sets & Accuracy of Calculation, &* *1 m from (c) Correct Trend*		

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(c)	<u>Graph: Scale, Size & Axes</u> □ Sensible scales, no **awkward scales** (eg 3 units into 10 small squares) □ Plots occupy **at least ½ of graph grid in both x & y directions** □ Successive scale markings: **no more than 20 small squares apart**. □ Axes labelled with the quantity & unit	1	
(c)	<u>Plotting of Points</u> □ **ALL** observations in table must be plotted □ **Precise** to within **half a small square**. □ **Thickness** of plots (ie the crosses) ≤ ½ **small square**	1	
(c)	<u>Best fit line & Anomaly</u> □ Line drawn with **approx. equal number of points on either side** of line (anomalous pts not considered). □ ≥ **5 non-anomalous pts**, (ie **allow 1 anomalous** plot only if 6 are plotted; anomaly must be **<u>clearly indicated</u>** (eg by a circle or labelled.) □ Line is **not kinked/ disjointed** or **thicker than ½ small square** □ **Correct Trend**: straight line with positive gradient	1	
(c)	<u>Linearisation of Eqn</u> □ Stated **explicitly**: $\frac{1}{2R_x}$ = **gradient** of graph (of I_1/I_2 vs R_Y)	1	
(c)	<u>Determination of Gradient and R_X</u> □ **Hypotenuse** of triangle > ½ length of line drawn □ **No obscurity of the 2 pts** used for gradient calculation (Hence for eg, these 2 pt on triangle must **not** be "highlighted") □ 1. Recorded the **4 coordinates** accurately to precision of **3 s.f.** 2. Recorded the **4 coordinates** to precision of ½ **small square** {ie the no. of dp for y-coordinates must follow no. of dp for ½ small sq for the y-scale & the no. of dp for x-coordinates must follow the no. of dp for ½ small sq for the x-scale }, 3. Recorded **x-coordinates** to **2 sf** (since R_Y is given to 2 sf), **or, 2 + 1 = 3 sf**; **y-coordinates** recorded to **3 sf** (since I_1 & I_2 are measured to 3 sf), **or, 3 + 1 = 4 sf** } □ R_X determined correctly from graph { $= \frac{1}{2x\ Gradient}$ } & recorded to **2 sf** (since R_Y has 2 sf), **3 s.f. or 4 s.f.** □ **Unit for R_X: Ω**	1	
(d)	□ When $R_Y = R_X$, $I_1/I_2 = 1$. □ Value of R_X is that value of R_Y where $I_1/I_2 = 1$ *{which is read-off the graph.}*	1	

(e)	<u>Analysis</u> □ line W: **below original graph** (ie **no intersection**) with a **gentler gradient**. {Explanation: gradient = $\frac{1}{2R_x}$, so when R_X increases, gradient decreases. Y-intercept is unchanged (at ½) }	1	
	Total	11	

Mark Scheme of Q3 of Prelim Pract 2022
(Time interval betw successive in-phase positions of 2 pendulums)

	Marking Point	Mark	Score
(b)(i)	Measurement and Observation { l about 0.5 m} □ Recorded ≥ **2 values** of l and **average** to **nearest mm,** 0.1 cm or 0.001 m. □ Accuracy: **0.450 m ≤ l ≥ 0.550 m**	1	
(b)(ii)	□ {Challenging condition} hence, **Δl = 3 - 5 mm** □ Calculated percentage uncertainty, $\frac{\Delta l}{l}$ x 100% = (value ≈ 0.6) **(1 or 2 sf)** {Considered 'challenging' because it's a measurement to an **inaccessible pt** (centre of bob)}	1	
(c)(i)	Measurement and Observation □ Accuracy: **10 s ≤ t ≥ 17 s** □ Recorded ≥ **2 values of *t*,** and **ave** to **nearest 0.1 s if Δt ≤ 2 .0 s** {**If Δt > 2 .0 s,** *t* shd be recorded to the **nearest 1 s** }	1	
(c)(ii)	□ Δt = **0.3 to 0.5 s if Δt ≤ 2 .0 s** {Challenging condition} = **½ the Range,** if **Δt > 2 .0 s {Very Challenging condition}** □ Calculated percentage uncertainty, $\frac{\Delta t}{t}$ x 100% = …….. **(1 or 2 sf)**	1	
(d)	□ Recorded ≥ **2 values** of l and **average** to **nearest mm,** 0.1 cm or 0.001 m. { l about 0.4 m} □ Recorded ≥ **2 values of *t*** to **nearest 0.1 s if Δt ≤ 2 .0 s** {**If Δt > 2 .0 s,** *t* **shd be recorded to the nearest second}**	1	
	□ Value of *t* should be **smaller than that in (c)(i).** {Accuracy: not assessed; FYI 5.5 s ≤ t ≥ 6.5 s }	1	
(e)(i)	□ Calculated correctly **two values** of *k* **with unit** and recorded to the **least no. of sf among *t* and l** {or 1 more}. □ **Unit: $m^{0.5}$ s^{-1}**	1	
(e)(ii)	□ E.g. "*Since the* **(measured)** **quantity with the least number of sf**, ***which is*** *{either t or l }, (has x significant figures), I recorded k also to x significant figures { or x +1 more }."*	1	
(e)(iii)	of Relationship □ Calculated $\frac{\lvert k_1 - k_2 \rvert}{k_{ave}}$ x 100 % correctly	1	

	□ Compared $\frac{\lvert k_1 - k_2 \rvert}{k_{ave}}$ x 100 % with the **sum** **of half the value of (b)(ii) and that of (c)(ii) &** concluded that **results do not support the suggestion** if $\frac{\lvert k_1 - k_2 \rvert}{k_{ave}} > ½ (\frac{\Delta l}{l}) + \frac{\Delta t}{t}$ or, **results support the suggestion** if $\frac{\lvert k_1 - k_2 \rvert}{k_{ave}} \le ½ (\frac{\Delta l}{l}) + \frac{\Delta t}{t}$	1	
(e)(iv)	□ Number of times calculated correctly: = $\frac{60}{t}$ where $t = \frac{\sqrt{l}}{k}$, l = 0.1 m & value of *k* to be used = **average** of k_1 & k_2 .	1	
(f)	• It is difficult to judge *when* pendulums are exactly lined up (as this occurs only at an instant in time & there is parallax error), or , • It is difficult to measure the length l since the cg of the bob is inaccessible, or, • 2 values of k are not enough to draw a valid conclusion on whether k is a const.	1	
(g)(i)	Plotting of Points □ **ALL 5** observations in table must be plotted □ **Precise** to within **half a small square.** □ **Thickness** of plots (ie the crosses) **≤ ½ small square**	1	
	Best fit line & Anomaly □ Line drawn **with approx. equal number of points on either side** of line (anomalous pts not considered). □ Line is **not kinked/ disjointed** or **thicker than ½ small square**	1	
(g)(ii)	□ Stating either the y-intercept, or, the x-intercept is not zero	1	
	□ Correct explanation for deduction above: Eg. Value of the x-intercept (1.24 $m^{-1/2}$) is significantly far from x = 0 (read from graph or by calculation). (FYI: gradient ≈ 0.5 $m^{0.5}$ s^{-1} & y-intercept ≈ -0.62 s^{-1})	1	
	□ Correct conclusion based on correct deduction that y-intercept is not zero: Since graph does not pass through the origin, $\frac{1}{t}$ is not directly proportional to $\frac{1}{\sqrt{l}}$.	1	

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(h)	<u>Appropriate measuring instruments used:</u> ☐ Measure length of pendulum using a **metre rule**, & measure oscillation time using a **stopwatch**.	1	
	<u>Procedure</u> ☐ Measure **time for *N* oscillations** using a stopwatch and **calculate period *T*. Formula for T** must be cited. ☐ **Repeat** the experiment for **different values of *L***	1	
	<u>Analysis</u> ☐ Either, • Plot graph of T against $\sqrt{L}$: ⇒ P = gradient, or • Plot lg T against lg L : ⇒ lg P = y-intercept. ⇒ $P = 10^{y\text{-intercept}}$	1	
	Total	20	

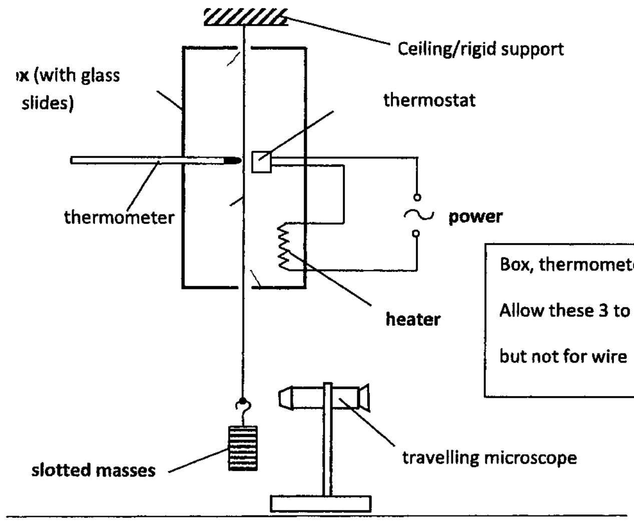
Q4 Mark Scheme and Examiner's Comments

<u>Independent & Dependent Variables</u> Independent variables: **Temperature *T*** of wire (Expt 1), **load *m*** supported by wire (Expt 2) Dependent variable: **Change in length Δ*L*** of wire (both Expts 1 & 2)	1	
<u>Control of Variables</u> (both expts): { Any 1} 1) Initial length of the wire is **<u>kept constant</u>**. 2) Diameter/cross-sectional area {not: thickness} of wire is <u>kept constant</u>. 3) Duration/time of heating of wire is <u>kept constant</u>.	1	

Labelled diagram of workable experiment showing: wire subjected to a load (masses) **along its length**, in a long box; electrical heater (in the box) **with power supply**. No need to show thermometer.	1	
• Use of a **thermostat** to set temperature. {Must be **<u>explicitly stated</u>**}.	1	
• Measure **mass *m*** using mass **<u>balance</u>** & measure **temperature *T*** using **<u>thermocouple</u>** (or **<u>thermometer</u>**). (If slotted masses are used, no measuring instrument for mass is required.)	1	
• Measure **extension of wire** using a **<u>travelling microscope</u>**.	1	
<u>Expt 1:</u> **Keeping mass *m* constant, vary temperature *T* <u>by changing thermostat setting or the power/voltage supplied to heater.</u>**	1	
<u>Expt 2</u>: **Keeping temperature *T* constant, vary mass *m* <u>by changing the number of slotted masses.</u>**	1	
<u>Analysis</u> { $\Delta L = k\,T^p m^q \Rightarrow \lg \Delta L = p \lg T + q \lg m + \lg k$ } For constant m *(Expt 1)*, plot **graph of lg Δ*L* against lg *T*, ⇒ *p* = gradient**	1	
For const T *(Expt 2)*, plot **graph of lg Δ*L* against lg *m*, ⇒ *q* = gradient**	1	
<u>Precautions to Improve Safety</u> (Any one) Use <u>goggles to protect the eyes</u> (in case wire snaps). Use <u>tongs or heatproof gloves to handle the hot wires</u> (e.g. when there is a need to keep the wire from moving while measuring extension). Set up apparatus (vertically) above a bucket of sand (to reduce impact on the ground in case wire snaps).	Max 1	
<u>Precautions to improve Accuracy/Additional Details/Good Design Features</u> (Any two) Perform a <u>preliminary experiment</u> <u>to gauge the range of loads</u> that can be used to produce a <u>measurable change in length</u> without causing wire to snap. Use a <u>kink-free wire</u> OR a <u>fresh wire</u> after each reading.	Max 2	

Use a long wire to obtain measurable extensions. Perform the experiment over a sufficiently long period of time to obtain measurable extensions. Check periodically to ensure that the point of suspension of wire at the ceiling does not sag (due to excessive weight of the suspended masses). If thermostat is not used, wrap the box with lagging material (to minimize heat loss)		
Total	13	

Diagram: Suggested setup: (N2000 P4 Q3)



Box, thermometer & circuit :

Allow these 3 to 'float in air'

but not for wire

BP~469