Tampines Meridian Junior College

2022 JC2 H2 Physics Prelim Exam Paper 1 – Suggested Solution

1	A	11	D	21	C
2	D	12	A	22	A
3	C	13	C	23	A
4	B	14	B	24	B
5	C	15	D	25	A
6	C	16	B	26	B
7	C	17	D	27	D
8	D	18	B	28	B
9	D	19	A	29	C
10	A	20	D	30	C

1. **Ans: A**

A: $(1\times10^{6})(1\times10^{-9})=1\times10^{-3}$

B: $(1\times10^{9})(1\times10^{-6})=1\times10^{3}$

C: $(1\times10^{-3})(1\times10^{3})=1\times10^{0}$

D: $(1\times10^{-3})(1\times10^{12})=1\times10^{9}$

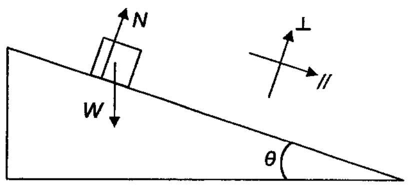
2. **Ans: D**

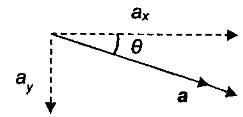
$\tan\alpha$ is unitless.

Therefore, Q is unitless,

and P must have the same units as $\sqrt{M}$, hence the units of P is $\text{kg}^{\frac{1}{2}}$.

3. **Ans: C**





$$\overline{F_{net}}=m\vec{a}$$
$$\overline{W}+\overline{N}=m\vec{a}$$
$$\begin{pmatrix}W_{//}\\W_{\perp}\end{pmatrix}+\begin{pmatrix}N_{//}\\N_{\perp}\end{pmatrix}=m\begin{pmatrix}a_{//}\\a_{\perp}\end{pmatrix}$$
$$\begin{pmatrix}mg\sin\theta\\-mg\cos\theta\end{pmatrix}+\begin{pmatrix}0\\N\end{pmatrix}=m\begin{pmatrix}a\\0\end{pmatrix}$$
$$a=g\sin\theta$$

$$a_y=a\sin\theta$$
$$=(g\sin\theta)(\sin\theta)$$
$$=g\sin^2\theta$$

4. **Ans: B**

$$\Delta p=\text{impulse}$$
$$p_f-p_i=\text{area under F-t graph}$$
$$m(v_f-v_i)=10(0.5)+5(0.5)$$
$$3(v_f-0.50)=7.5$$
$$v_f=3.0\ \text{m s}^{-1}$$

5. **Ans: C**

By Newton's second law, the change in momentum of the gas will result in a force on the gas.
By Newton's third law, the force on the rocket will have the same magnitude but opposite direction to the force on the gas

6. **Ans: C**

As the normal contact force (i.e. the reading on the scale) is more than the weight of the sack, the lift must be moving upwards and its acceleration must be pointing upwards.

$$N-W=ma$$
$$N=mg+ma$$

Considering the forces acting on the sack only:

$$N-W=ma$$
$$12(9.81)-10(9.81)=10a$$
$$a=1.96\ \text{m s}^{-2}$$

7. **Ans: C**

$$\text{Energy} = \frac{1}{2}mv^2 = \frac{1}{2}m(u+at)^2 = \frac{1}{2}m(a^2)(t^2) \quad \text{since } u \text{ is zero}$$
$$= \text{constant} \times t^2$$

8. **Ans: D**

Using COE:

$$E_i = E_f$$
$$GPE_i = KE_f$$
$$mgr = \frac{1}{2}mv^2$$
$$2mgr = mv^2 \quad \text{------------- (1)}$$

$$T_{bottom} - mg = \frac{mv^2}{r}$$
$$T_{bottom} = \frac{mv^2}{r} + mg \quad \text{sub (1) into eqn}$$
$$= \frac{2mgr}{r} + mg$$
$$= 3mg$$

9. **Ans: D**

The gravitational potential at the point near the stars is given by

$$\phi = -\frac{2GM}{r}$$

The kinetic energy of the rock is found using energy conservation:

$$KE_\infty + PE_\infty = KE_r + PE_r$$
$$0 + 0 = \frac{1}{2}mv^2 - \frac{2GMm}{r}$$
$$v = \sqrt{\frac{4GM}{r}}$$

10. **Ans: A**

The total energy in the oscillation is given by:

$$E_T = \frac{1}{2}m\omega^2 x_0^2 = (0.5)(2)(2\pi(2.5))^2(0.05)^2 = 0.617 \text{ J}$$

Hence the potential energy is:

$$E_p = 0.617 - 0.36 = 0.26 \text{ J}$$

11. **Ans: D**

First, deduce that, at that instant, P has velocity downwards and speed maximum.
So initial velocity is negative maximum, so answer D.

12. **Ans: A**

Distance between the two points along the wave (perpendicular to wavefront) = 8.0 sin 30°

phase difference $\phi = \frac{x}{\lambda} \times 360° = \frac{8.0 \sin 30°}{40} \times 360° = 36°$

13. **Ans: C**

Condition for maxima: path difference = $n\lambda$ (and $\lambda = \frac{v}{f}$)

At one maxima: $2.9 = n\frac{v}{800}$ (1)

At next maxima: $2.9 = (n+1)\frac{v}{960}$ (2)

Solve simultaneously gives v = 460 m s^{-1}

Note: speed of sound is different in different medium, in air it is 340 m s^{-1}, in water it is 1500 m s^{-1}, in glass 4540 m s^{-1}, in hydrogen 1320 m s^{-1}, in neon it is 460 m s^{-1}.

14. **Ans: B**

fringe separation $x = \frac{\lambda D}{a}$

x is big if λ big, D big and a small

15. **Ans: D**

bottom of first air column is node, second air column is one node (or one loop) further down
so difference between two air column lengths = node to node distance

$$\therefore y - x = \frac{\lambda}{2}$$
$$\Rightarrow \lambda = 2y - 2x$$

16. **Ans: B**

$$p = \frac{1}{3}\frac{Nm}{V}\langle c^2\rangle$$

Since V and Nm are constant, $p \propto \langle c^2\rangle$

$$\frac{4p}{p} = \frac{\langle c_{new}{}^2\rangle}{\langle c^2\rangle}$$

$$\sqrt{\langle c_{new}{}^2\rangle} = \sqrt{4\langle c^2\rangle} = 2c$$

17. **Ans: D**

$$mc\frac{\Delta\theta}{t} = \frac{m}{t}L$$

$$\frac{L}{c} = \frac{\Delta\theta}{t}(t) = 4\times 40 = 160$$

18. **Ans: B**

$\Delta U = W + Q$

The work done by the gas is greater in (ii) than in (i) since area under (ii) is greater than that of (i).

The increase in internal energy in (i) is same as (ii) since $\Delta(pV) \propto \Delta T$ and $\Delta U \propto \Delta T$.

19. **Ans: A**

Test charge is introduced at a point to determine the electric field strength and it should not alter the electric field at that point.

20. **Ans: D**

$$eV_- + \frac{1}{2}mv^2 = eV_+ + \frac{1}{2}mv_f{}^2$$

$$e(V_- - V_+) + \frac{1}{2}mv^2 = \frac{1}{2}mv_f{}^2$$

$$\frac{2e(V_- - V_+)}{m} + v^2 = v_f{}^2, (V_- - V_+) = -Ex$$

$$v_f = \sqrt{\frac{2e(-Ex)}{m} + v^2}$$

OR

$$\frac{1}{2}mv^2 + W_{electric.force} = \frac{1}{2}mv_f{}^2$$

$$\frac{1}{2}mv^2 + (F_{electric.force}.x)\cos 180^0 = \frac{1}{2}mv_f{}^2, [F_{electric.force} \text{ and } x \text{ opposite direction}]$$

$$\frac{1}{2}mv^2 + -(eE.x) = \frac{1}{2}mv_f{}^2$$

$$v_f = \sqrt{\frac{2e(-Ex)}{m} + v^2}$$

21. **Ans: C**

Resistance is the ratio of V/I, where the change of resistance is taking the resistance at point Y – resistance at point X, which is $\frac{V_Y}{I_Y} - \frac{V_X}{I_X}$

22. **Ans: A**

$$V_{R_1} = \frac{0.6}{1.0}V_{p.wire}$$

$$V_{R_2} = \frac{0.2}{1.0}V_{p.wire}$$

$$\frac{V_{R_2}}{V_{R_1}} = \frac{IR_2}{IR_1} = \frac{\frac{0.2}{1.0}V_{p.wire}}{\frac{0.6}{1.0}V_{p.wire}}$$

$$\frac{R_2}{R_1} = 0.33$$

23. **Ans: A**

$$F_{P\text{ on }Q} = B_P I_Q L_Q$$

$$\frac{F_{P\text{ on }Q}}{L_Q} = \frac{\mu_0 I_P}{2\pi d}I_Q$$

24. **Ans: B**

$$\tau = F\times d$$
$$= BIL\times w$$

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25.	**Ans: A** By Lenz's law, an induced current will flow in the loop such that it opposes the increase in the magnetic flux linkages producing it. When loop starts to enter the region of magnetic field, loop experiences an upwards retarding force larger than its weight and hence decelerate. Since the loop and the region of magnetic field has the same height d, there will not be a time interval which the entire loop remains in the field. When the loop is leaving the region of magnetic field, the magnetic flux linkages through the loop decreases, hence the induced current is such that it opposes the decrease in the magnetic flux linkages. → induced current is now in the opposite direction but force is still upwards.
26.	**Ans: B** Fuse breaks depends on current and the root-mean-square (r.m.s.) current of the a.c is same as that of the steady d.c.
27.	**Ans: D** Some of the magnetic field lines produced by the primary coil do not link well with the secondary coil, reducing the e.m.f. induced in the secondary coil. The presence of iron core maximises the flux linkage between the primary and secondary coils.
28.	**Ans: B** K_{max} = 0 eV occurs when λ = 300 nm. Therefore, the threshold wavelength is 300 nm. By photoelectric equation, $\Phi = \frac{hc}{\lambda} - E_{K}max$ $= \frac{6.63\times10^{-34}(3.0\times10^{8})}{300\times10^{-9}} - 0$ $\Phi = 6.63\times10^{-19}$ J $= 4.14$ eV

29.	**Ans: C** $p = mv$ $\frac{\Delta p}{p} = \frac{\Delta m}{m} + \frac{\Delta v}{v}$ $\frac{\Delta p}{p} = \frac{\Delta v}{v}$ $(\because \Delta m = 0)$ $\Delta p \Delta x \gtrsim h$ $\left(\frac{9.11\times10^{-31}v}{100}\right)\left(\frac{0.20}{1000}\right) \gtrsim 6.63\times10^{-34}$ $v = 364$ m s^{-1}
30.	**Ans: C** For sample X: $A = \lambda_A N$ For sample Y: $3A = \lambda_Y N$ and since for half life $\lambda = \frac{\ln 2}{t_{\frac{1}{2}}}$ we can combine the equations as follows: $A = \frac{\ln 2}{t_{1/2(X)}} N$ $3A = \frac{\ln 2}{t_{1/2(Y)}} N$ $\frac{3A}{A} = \frac{\frac{\ln 2}{t_{1/2(Y)}} N}{\frac{\ln 2}{t_{1/2(X)}} N}$ $3 = \frac{t_{1/2(X)}}{t_{1/2(Y)}}$

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2022 JC2 H2 Physics Prelim Exam Paper 2 – Suggested Solution

1	**(a)**		units of $v^2 = (\text{m s}^{-1})^2 = \text{m s}^{-2}$ units of $u^2 = (\text{m s}^{-1})^2 = \text{m s}^{-2}$ units of $2as = \text{m s}^{-2} \times \text{m} = \text{m s}^{-2}$ Since the units of all the terms are the same, the equation is homogenous. B1 units of v^2, u^2, and $2as$ B1 for presentation	
			Comments: Students lost marks due to incorrect presentation.	
	(b)	**(i)**	$v^2 = u^2 + 2as$ $a = \frac{v^2}{2s}$ $= \frac{7.7^2}{2(5)}$ $= 5.929$ $= 5.9 \text{ m s}^{-2}$ B1	
			Comments: Well done	
		(ii)	$a = \frac{v^2}{2s}$ $\frac{\Delta a}{a} = 2\frac{\Delta v}{v} + \frac{\Delta s}{s}$ $\Delta a = (5.929)\left(2\frac{0.3}{7.7} + \frac{0.2}{5.0}\right)$ C1 $= 0.7 \text{ m s}^{-2}$ A1	
			Comments: There were 3 common mistakes here: (i) absolute uncertainty Δa must be 1 s.f. (ii) $\frac{\Delta a}{a} \neq 2\frac{\Delta v}{v} - \frac{\Delta s}{s}$, uncertainty always add up! Must always make '*a*' the subject first. (iii) $\frac{\Delta a}{a} \neq 2\frac{\Delta v}{v} + 2\frac{\Delta u}{u} + \frac{\Delta s}{s}$, cannot include $2\frac{\Delta u}{u}$, this is wrong method.	

			Recall from notes: **Multiplication/Division** If $X = nA^\alpha mB^\beta$ or $X = \frac{nA^\alpha}{mB^\beta}$, where α, β, *m* and *n* are numbers, then $\frac{\Delta X}{X} = \alpha\frac{\Delta A}{A} + \beta\frac{\Delta B}{B}$ Hence this is strictly for multiplication/division. If students added initial velocity '*u*' into the equation then the equation is no longer purely multiplication/division, then this formula cannot be used.	
		(iii)	$(5.9 \pm 0.7) \text{ m s}^{-2}$	B1
			Comments: A good number of students forgot the rules when writing answer in this form. The absolute uncertainty Δa must be 1 s.f. The quantity *a* must be same d.p as Δa.	
	(c)	**(i)**	P: Accuracy is defined as how close readings are to their true value. S: Since the average position/point of impact of arrows of Bowman A are closer to the center of the target, compared to bowman B [M1] T: Bowman A is more accurate. [A1]	
			Comments: The main mistake was not including the word "average".	
		(ii)	P: Precision is defined as how close readings agree with each other. S: Since the arrows of Bowman B are closer to each other compared to bowman A [M1] T: Bowman B is more precise. [A1]	
			Comments: Well done.	

BP-662

2	(a)	By Newton's third law, both vehicles experience the same magnitude of impact force	B1
		Comments: Very poorly attempted. Majority of students did not realised that the force is the same.	
	(b)	As there are no resultant external forces acting on the system of both the bus and car, hence the total momentum of the system is conserved during the entire collision.	B1
		Since the initial total momentum of the two vehicles is not zero, hence the final momentum of the two vehicles will also not be zero. Both vehicles will not be at rest at the same instant.	B1
		Comment: Many students only got 1 out of 2 marks as one of the 2 points were missing. For the first point, the common mistake was missing out one of these words "resultant" or "external". Both words must be included (it is in the definition). Also students should also state what their system is, in this case to mention considering both the bus and car. For the second point, students should mention that the "initial" momentum was not zero and not simply saying total momentum not zero, how do you know that the total momentum is not zero. Answers need to be clear.	
	(c)	$P_i = P_f$ $5m(19.4)+m(-19.4)=(5m+m)v$ M1 $v = 12.9 \text{ m s}^{-1}$ A1 Direction: to the right B1	
		Comments: Students were able to apply the concept of conservation of momentum here correctly. However, many did not convert km h^{-1} to m s^{-1}.	
	(d)	The car reverses its direction, hence it has a greater change in velocity than that of the bus. Or show $\Delta v_{car} = v_f - v_i = 12.9-(-19.4) = 32.3 \text{ m s}^{-1}$ and $\Delta v_{bus} = v_f - v_i = 12.9 - 19.4 = -6.5 \text{ m s}^{-1}$.	M1
		Since both dummies have the same mass, hence change in momentum of the driver is directly proportional to the change in velocity experience by the driver, hence, the dummy in the car experiences a greater change in momentum	A1
		Comments: Please avoid using just symbols, explain what your symbols represent! (this was marked leniently)	

		Many students seemed to be confused for this part. And some tried to calculate the change in momentum for bus and car instead of the dummies in them. Please note that the change in momentum for both bus and car will be the same, that's why the experience the same impact force. $F = \frac{dp}{dt}$ However, the change in velocity for both car and bus will be different. Those who calculated the change in velocity, need to take note of the proper sign convention and calculate the change in velocity properly using $\Delta v = v_{final} - v_{initial}$, use proper sign convention when calculating.	
	(e)	fractional energy lost $= \frac{KE_{lost}}{KE_{initial}}$ $= \frac{KE_i - KE_f}{KE_i}$ $= \frac{\frac{1}{2}mv_i^2 - \frac{1}{2}mv_f^2}{\frac{1}{2}mv_i^2}$ $= \frac{v_i^2 - v_f^2}{v_i^2}$ $= \frac{19.4^2 - 12.9^2}{19.4^2}$ M1 $= 0.558$ A1	
		Comments: Poorly attempted. Question clearly stated to find the energy lost BY THE CAR only, hence the working needs to clearly show this.	

3	(a)	(i)	Diffraction is the spreading of light waves after it passes through an aperture (of the diffraction grating)	B1
		(ii)	The light from the (adjacent) slits/lines have a constant phase difference between them and same frequency.	B1
		(iii)	Superposition occurs when 2 or more light waves of the same kind (or type), meet (or overlap), the resultant displacement is the vector sum of the displacements of the individual light waves at that point.	B1 B1
			*If no reference to light, deduct 1 mark Comments: Students should make reference the diffracted light as mentioned in the question. (a)(i): Words such as bending, splitting and scattering are not acceptable.	

			(a)(ii): Phrases such as in phase and zero phase difference are not acceptable. Monochromatic light source only implies same frequency which is not necessarily same as constant phase difference. It is the diffracted light that is coherent. (a)(iii): Superposition is about the resultant displacement at every point and not just the amplitude.	
	(b)	(i)	Maximum angle for the 2nd order happens when wavelength is the longest at 650 nm, $d\sin\theta = n\lambda$ $\frac{1\text{x}10^{-3}}{500}\sin\theta = 2(650\text{x}10^{-9})$ M1 $\theta = 40.5°$ A1	
		(ii)	$d\sin\theta = n\lambda$ $\frac{1\text{x}10^{-3}}{500}\sin\theta = 3(350\text{x}10^{-9})$ $\theta = 31.7°$ B1	
			Comments: Some students used the wrong formula or calculated d wrongly.	
		(iii)	This means that there is an overlap of fringes between the 2nd order maxima and 3rd order minima for white light and is difficult to view fringes of specific wavelengths since they are mixed up.	B1
			Comments: Difficult to view and fringes are mixed up are problems due to the overlapping of the fringes. Fringes being very close to one another is not the same as overlap.	
		(iv)	250 lines per mm means d has increased by 2 times $d\sin\theta = n\lambda$ $n_{max} \le \frac{d}{\lambda}$ Slit separation d is increased by 2 times (or doubled), the average separation of the fringes decreases or angle θ for each order is halved. This means maximum order of fringes n is increased by up to 2 times (or doubled).	B1 B1
			Comments: If specific value(s) (eg. 250 lines per mm) is given in the question, students should make use of the value(s) in their answers and describe the specific	

			change(s). There is insufficient information to ascertain the effect on brightness/contrast of the fringes.	
4	(a)	(i)	$n = \frac{N}{Volume} = \frac{3.2\text{x}10^{22}}{3.0(1.3\text{x}10^{-7})} = 8.2\text{x}10^{28}$	B1
			Comments: Most students answered this correctly, except for a few which made transfer or calculation errors.	
		(ii)	$I = nAve$ $v = \frac{I}{nAe} = \frac{0.80}{8.2\text{x}10^{28}(1.3\text{x}10^{-7})(1.6\text{x}10^{-19})}$ M1 $= 4.7\text{x}10^{-4}$ m s^{-1} A1	
			Comments: Most students did well for this part, except some are confused over n.	
	(b)	(i)	$V_w = IR = (0.80)(0.40) = 0.32$ V C1 Potential divider $V_w = \frac{R}{R+r}E$ $0.32 = \frac{0.40}{0.40+r}(0.48)$ $r = 0.20\ \Omega$ A1	
			Comments: most students who use $V = E - IR$ and got the correct answer were accepted.	
		(ii)	$\%\ loss = \frac{I^2r}{I^2(r+R)} = \frac{0.20}{0.60} = 0.33 = 33\%$	B1
			Comments: Reasonably well done. Some students failed to read the question and calculated power delivered to R instead while some others failed to include r in the total resistance in the denominator.	
	(c)	(i)	Wire Y has smaller resistance Overall current in circuit increases Drift velocity is greater.	M1 A1
			Comments: quite badly done as quite a number of students thought that a shorter wire will change charge density instead of resistance.	

		(ii)	$\%loss = \frac{I^2 r}{I^2(r+R)} = \frac{r}{(r+R)}$ which is the ratio of internal resistance to total resistance. % losses increases when R decreases, efficiency decreases when wire Y is used *ecf if (c)(i) R increases	M1 A1
			Comments: Badly attempted, as many did not mention % of power loss is related to the ratio of internal resistance to total resistance. Many spoke about the increase in current when total resistance decrease, resulting in greater power loss, without considering that total power has also increased. As such, full credit was not given. There is also another group which reference the ratio of p.d to ratio of resistance using potential divider but did not relate that back to the efficiency. A handful spoke about the external resistance being closer to internal resistance, resulting in greater power output (using max power theorem), not knowing input power has also changed. As such, they are not able to make correct conclusion about efficiency.	

5	(a)	(i)	$B = \mu_o nI$ $= (4\pi \times 10^{-7})\left(\frac{400}{0.35}\right)(2.3)$ [B1] $= 3.3 \times 10^{-3}$ T	
			Comments: Well done. Some students wrongly employed the equation for the flat circular coil, when the radius of the coil was not provided, and the context of the question referred clearly to a solenoid. A solenoid is sometimes also referred to as a coil, so one must be clear which is being dealt with.	
	(b)	(i)	The component of velocity perpendicular to the magnetic flux density results in a uniform circular motion. The component of velocity parallel to the magnetic flux density / along the axis is constant. These two motions give rise to helical motion.	B1 B1
			Comments: Some students were able to do this well.	

			Students who did not get the marks here lacked specificity in discussing the PARALLEL and PERPENDICULAR components of velocity.	
		(ii)	Magnetic force provides for centripetal force [B1] $Bqv_{\perp} = mR\omega^2$ $Bqv_{\perp} = m(R\omega)\omega$ $v_{\perp} = R\omega$ and $\omega = \frac{2\pi}{T}$ [C1] $Bqv_{\perp} = mv_{\perp}\omega$ $T = \frac{2\pi m}{Bq}$ $= \frac{2\pi(1.67 \times 10^{-27})}{(3.3 \times 10^{-3})(1.6 \times 10^{-19})}$ [M1: subs] $= 1.9873 \times 10^{-5}$ $\approx 20 \times 10^{-6}$ s [A0] for reference: $v_{//} = 2287.4$ m s^{-1} $v_{\perp} = 3522.4$ m s^{-1} $F_B = 1.8598 \times 10^{-18}$ N $R = 0.011140$ m $\omega = 3.1616 \times 10^5$ rad s^{-1}	
			Comments: There were many ways to solve this problem. It was nice to see correct but unexpected ways to solve it. Common errors • included not resolving the vertical component of velocity (4200 sin 57), resulting in a deduction. • students should use the rest mass of the proton.	
		(iii)	time in solenoid, $t = \frac{\text{length of solenoid}}{v_{//}}$ $= \frac{0.35}{4200\cos 57}$ $= 1.5300 \times 10^{-4}$ s [C1]	
			Comments: Well done. common errors • not resolving the horizontal component of velocity (4200 cos 57)	

		(iv)	number of cycles, $N = \frac{\text{time in solenoid}}{\text{period of helical motion}} = \frac{1.5300\times10^{-4}}{20\times10^{-6}} = 7.6992$ (7 complete cycles) [A1]	
			Comments: well done. Ideally, only an integer should be presented, based on "complete cycles".	
		(v)	Principle: $F_B = Bqv$ Since: Since the magnetic flux density outside the solenoid is weaker Therefore: F_B or the centripetal force decreases. Or since the radius is inversely proportional to magnetic flux density Resulting in an increase in radius.	M1 A1
			Comments: This question required students to recall the magnetic field lines of a solenoid without being instructed to draw it. common errors • Students did not recognise that magnetic flux density is still present outside the solenoid, albeit at a weaker value than inside the solenoid.	

6	(a)	Number of protons = 82 (start with 88, subtract 2 for every alpha decay and add 1 for every beta decay) Number of neutrons = 126 (Start with 224-88=136; subtract 2 for every alpha decay and subtract 1 for every beta decay)	B1 B1
		Comments: Many students forgot that beta decay also causes the number of neutrons to decrease.	

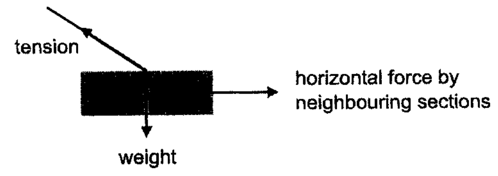
			Many students misread and answered with nucleon number instead of neutron number.	
	(b)	(i)	Initial number of nuclei = $\frac{12\times10^{-3}}{224}\times6.02\times10^{23} = 3.225\times10^{19}$ Decay constant $\lambda = \frac{\ln2}{t_{1/2}} = \frac{\ln2}{3.63\times24\times3600} = 2.21\times10^{-6}\ \text{s}^{-1}$ Initial activity = $\lambda N = 2.21\times10^{-6}\times3.225\times10^{19} = 7.13\times10^{13}\ \text{s}^{-1}$	C1 C1 M1 A1
			Comments: Many students forgot to work out the decay constant in second^{-1} and left it in day^{-1} which is incorrect. Many students also forgot that N is the number of molecules and not number of moles	
		(ii)	Mass of radium-224 nuclei remaining after 6.0 days $m = m_0\left(\frac{1}{2}\right)^{\frac{t}{t_{1/2}}}$ $m = 12\left(\frac{1}{2}\right)^{\frac{6.0}{3.63}}$ $= 3.8$ mg also accept methods using decay constant: decay constant for radium-224 = $\lambda = \frac{\ln2}{3.63} = 0.191\ \text{day}^{-1}$ Mass remaining after 6.0 days $m = 12e^{-0.191\times6.0}$ $= 3.8$ mg	 C1 A1 C1 A1
			Comments: Many students took a roundabout route by calculating activity level or number of nucleons, and had problems converting that into a mass equivalent.	
		(iii)	The half life of Lead-212 is much longer than the half life of Radon-220, and Radon-220 is decaying into Polonium-216 and producing Lead-212 nuclei, thus for these reasons the concentration of Lead-212 is higher than the concentration of Radon-220 at the time specified in the question.	B1 B1
			Comments:	

BP-665

			There are two main components to the answer: 1. Comparison of the half life of Radon-220 and Lead-212 2. An understanding that the decay chain results in Radon-220 leading to the production of more lead-212 nuclei	

7	(a)	better to have many cables supporting the load instead of relying on one very strong pair of cables taking the same load	B2
		Comments: Candidates are generally awarded marks for mentioning using many cables instead of relying on one pair.	
	(b)	maximum mass support by each tower $=\dfrac{(1.4+8.5+11.5)\times10^6}{2}$ C1 $=1.07\times10^7$ A1	
		Comments: 80% got this correct, the rest did not realise there are two towers so have to divide by 2.	
	(c)	$\dfrac{(8.5+11.5)\times10^6}{1600}\times20$ C1 $=2.5\times10^5$ kg A1	
		Comments: 90% got this correct.	
	(d)	$\tan^{-1}\dfrac{8}{20}$ C1 $=21.8°$ A1	
		Comments: 90% got this correct.	

(e)



	(e)	tension (to the left and 21.8° above horizontal) (of cables on either side—left and right—of the roadway)	B1
		(total) weight downwards	B1
		horizontal force to the right (by neighbouring sections)	B1
		it is in equilibrium with the resultant of the three forces being zero (award only if the forces drawn can balance)	B1
		Comments: 80% got tension and weight correct	
	(f)	↑ $T \sin 21.8° = 2.5\times10^5\times9.81$	C1
		$T = 6.60\times10^6$ N	C1
		this T is due to 2 cables on either side of the roadway so tension in each cable = $\dfrac{T}{2} = 3.30\times10^6$ N	A1
		Comments: Most got the value 6.60×10^6 N but did not realise there are two cables, one on each side of the road, so the tension in one cable has to divide by two.	
	(g)	increase in extension = $\dfrac{\text{increase in tension}}{\text{force constant}}$ $=\dfrac{5.2\times10^5}{7.0\times10^6}$ C1 $=0.074$ m A1	
		Comments: 90% got this correct.	
	(h)	This is to ensure the cable is not stretched beyond its elastic limit which would result in the cable being permanently deformed. Or Any relevant safety	B1
		Comments: Most are awarded marks mainly for mentioning situations where maximum tension allowed is exceeded so the buffer is in place.	

	(i)	middle of the roadway	B1
		because cables are pulling it in opposite directions	B1
		Comments: Very few got this right. Many misinterpreted the question, the question is not asking "why is there tension" (where many candidates went on to explain why is there tension) but the question is asking "**where** is there tension" (answer is at the middle of the roadway).	

Tampines Meridian Junior College

2022 JC2 H2 Physics Prelim Exam Paper 3 – Suggested Solution

1	(a)	(i)	Archimedes' Principle states that the upthrust on a body completely or partially submerged in a fluid is equal in magnitude and opposite in direction to the weight of the fluid the body displaces.	B1
			Comments: Generally well done. This part was leniently marked where only the underlined terms were required.	
		(ii)	Pressure increases with depth in a fluid. When an object is submerged in a fluid, bottom is at a greater depth than at the top, hence, the pressure is greater at the bottom than at the top of the object.	B1
			The difference in pressure results in a net upward force acting on the object, which is upthrust.	B1
			Comments: Most students were able to recall the origins of upthrust, however key terms underlined above were missing. Unfortunately, a good number of students had a very *serious misconception* here where Newton's third law and weight were used in the discussion. This is completely incorrect.	
	(b)		$F_{net} = 0$ $m_{total}g = U + F_{resistive}$ $m_{submarine}g + m_{seawater}g = \rho g V_{submarine} + F_{resistive}$ $4800(9.81) + m_{seawater}(9.81) = (1030 \times 9.81 \times 5) + 1100$ M1 $m_{seawater} = 462$ kg A1	
			Comments: Majority of students were able to identify that the $F_{net} = 0$ since the submarine is moving at constant speed. However, a good number of students were not able to come up with the terms found in F_{net}, which lead to errors in their working.	
	(c)	(i)	$P = P_o + \rho g h$ $= 1.01\times10^5 + (1030\times9.81\times200)$ M1 $= 2.12\times10^6$ Pa A1	
			Comments: Well done.	

		(ii)	$\Delta P = P_{outside} - P_{inside}$ $= 2.12\times10^6 - 1.01\times10^5$ M1 $= 2.02\times10^6$ Pa $F = \Delta P A = 2.02\times10^6(\pi\times0.150^2) = 1.43\times10^5$ N A1	
			Comments: Many students did not find the difference in pressure that is needed to counterbalance. Also many students very carelessly got the wrong formula for force.	

2	(a)		Gravitational potential at a point is the work done by an external force per unit mass to move a small point mass from infinity to that point without a change in kinetic energy.	B2
			Comments: necessary words: 1. work done 2. by an external force 3. per unit mass 4. small test mass / small point mass 5. without a change in kinetic energy.	
	(b)		$\Phi = -\frac{GM_{earth}}{r_1} - \frac{GM_{moon}}{r_2}$ C1 $\Phi = -\frac{6.67\times10^{-11}\times5.98\times10^{24}}{3.84\times10^8 - 1.74\times10^6} - \frac{6.67\times10^{-11}\times7.35\times10^{22}}{1.74\times10^6}$ M1 $= -3.86\times10^6$ J kg^{-1} A0	
			Comments: 1. Show substitution of values (show question) 2. Several students did not subtract radius of the moon, or subtracted radius of the earth instead.	
	(c)	(i)	Calculation of the gradient Taking adjacent values $\text{gradient} = \frac{(-1.95-(-1.97)\times10^6)}{(2.01-1.99)\times10^8}$ C1 $= 0.010$ N kg^{-1} A1	
			Comments: 1. The question clearly stated to use values from the table, yet few students did.	

BP-669

2. As there are multiple bodies (Earth, Moon), the solution $g = \frac{GM}{r^2}$ can't be used.

(ii) Gravitational force provides centripetal force

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

$$v = \sqrt{gr}$$

$$v = \sqrt{(0.010)(2\times10^8 + 6.38\times10^6)} \quad \text{C1}$$

$$= 1437 = 1440 \text{ m s}^{-1} \quad \text{A1}$$

(subtract one mark if the radius of the earth was not considered)

Comments:
1. The question clearly stated "hence", so you have to use the values from the previous question.

2. It's not correct to write $\frac{GMm}{r^2} = \frac{mv^2}{r}$ since there is more than one mass affecting the orbit.

3. It's also not correct to write $v = \sqrt{\frac{GM}{r}} = \sqrt{1.96\times10^6}$ as the value of potential is the net potential from two bodies, it doesn't fit the formula.

4. Once again, don't forget to add the radius of the Earth.

(d) The spacecraft requires at least enough kinetic energy to cross the maximum potential point at 3.40 x 10^8 m from the surface of the Earth.

$$KE_1 + PE_1 = KE_2 + PE_2$$

$$KE + m\Phi_1 = 0 + m\Phi_2$$

$$KE = 1000(-1.28 - (-62.5))\times10^6 \quad \text{M1}$$

$$= 6.12\times10^{10} \text{ J} \quad \text{A1}$$

Comments:

1. The spacecraft needs enough kinetic energy to reach the neutral point.
2. The question clearly stated to use the data from the table.
3. It's not correct to use $-\frac{GM}{r}$ as the GPE since there is more than one mass involved.

3 (a) The internal energy of a system is the sum of a random distribution of kinetic and potential energies associated with the molecules of the system. B1

Comments:
Well done.

Students who lost credit generally missed key terms such as "random distribution" and "molecules".

(b) (i) $Q = mc\Delta\theta$

$$= (1.28\times0.600)(1000)(390-275) \quad \text{C1}$$

$$= 88.3 \text{ kJ} \quad \text{A1}$$

Comments:
Well done.
On a rare occasion, students confused the specific heat capacity value for the air density value. This could be avoided with students writing quick legend describing the use of symbols.

(ii) $pV = nRT$ or NkT

$$V \propto T$$

$$\frac{V_1}{V_2} = \frac{T_1}{T_2}$$

$$\frac{0.600}{V_2} = \frac{275}{390}$$

$$V_2 = 0.850 \text{ m}^3 \quad \text{C1}$$

$$p\Delta V = (1.03\times10^5)(0.850-0.600) \quad \text{M1}$$

$$= 25.8 \text{ kJ} \quad \text{A0}$$

Comments:
Well done.

(iii) $\Delta U = W + Q$

$$= -25.8 + 88.3 \quad \text{M1 (allow ecf from (i))}$$

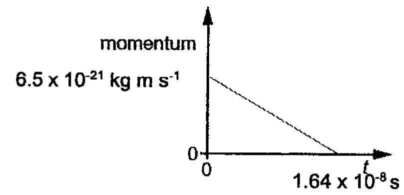
$$= 62.5 \text{ kJ} \quad \text{A1}$$

(Cannot use $E_K = 3/2NkT$ since air in this question is not monatomic)

Comments:
Students who lost credit, was commonly due to failing to apply W as a loss in energy of the system.

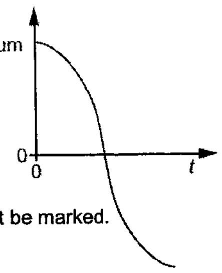
	(c)	By the First Law of Thermodynamics Since air compressed: work done on air (W) is positive and since process is sudden: no heat flow (or Q is zero) OR Due to collisions with moving piston, average kinetic energy of gas molecules increases and since process is sudden: no heat flow (or Q is zero) Therefore, internal energy is proportional to temperature, hence temperature increases.	M1 M1 (M1) (M1) A1
		Comments: Moderately well done. Common mistakes: • Failure to consider the implication of the "sudden" nature of the process • an increased "frequency of collisions" does not strictly "increase the kinetic energy" of molecules. The molecules could be moving very slowly but colliding frequently in a confined space.	

4	(a)	To the left or from B to A	B1
		Comments: A handful of students fail to realise that for electric force, the electric field has to be parallel to the electric force and gave answers like upward or downwards. In the case of positive charge, the electric field and electric force has to be in the same direction.	
	(b)	$v^2 = u^2 + 2as$ $0^2 = (3.9\times10^6)^2 + 2a(0.032)$ M1 $a = -2.38\times10^{14}$ A1 Accept if student uses work done = loss of K.E	
		Comments: Many lost marks due to transfer error in v^2. Misconceptions can be seen when students use s/v to find t, which should not be used when there is (constant) acceleration involved due to uniform electric field.	

	(c)	$F = Eq$ $ma = Eq$ $E = \frac{ma}{q} = \frac{1.67\times10^{-27}(2.38\times10^{14})}{1.6\times10^{-19}}$ C1 $E = 2.48\times10^6$ A1 Accept if student uses q(V) = q(Ed) = loss in K.E	
		Comments: Surprisingly, many students use the inverse square law used for point charges (conceptually erroneous), instead of recognising context of a uniform electric field. A few are not aware of the mass and/or charge of proton while some equate the electric force to the weight of the charge, which is not even mentioned in the context.	
	(d)	 B2 for correct axis labels (one for momentum, one for time) B1 for shape	
		Comments: under constant acceleration, there is a constant net force, which will cause a linear change in momentum. Generally, this part is well done, except that values on the axes were calculated wrongly.	
	(e) (i)	The proton will not reach point B/come to rest before point B for Fig 4.3. (due to the increasing electric force of repulsion as proton travels towards charge.) OR Momentum/velocity for proton is lower at point A for Fig 4.3. (since electric force acts before reaching point A.) OR The deceleration for proton is not constant for Fig 4.3. (it experiences increasing deceleration in the direction of travel.)	B1
		Comments: Generally well done, since a variety of answers are accepted. It is important to know that in both cases in 4.1 and 4.3, when the proton comes to a stop, it will reverse its motion.	

BP-671

(ii)



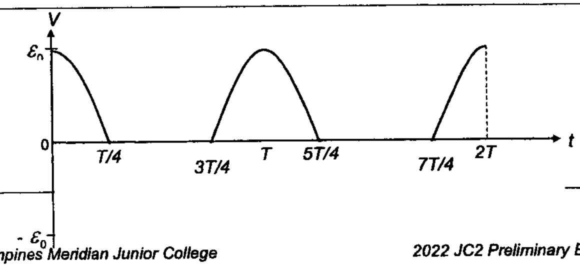
The negative part will not be marked.

The gradient of the graph gives resultant force (electric force) and it increases closer to the charge.

B1 for shape (note: the gradient at time = 0 cannot be horizontal since the electric force is not zero and the gradient at momentum = 0 cannot be vertical)

Comments: Students who realise that the gradient of the graph should reflect the magnitude of the electric force (Fnet) which increases as the proton travels. The negative section of the graph is relevant (since the proton reverse its motion) but it will not be marked.

5	Comments: There is a need to be clear whether it is flux density, flux or flux linkage (and to know which one is a vector or scalar). Some students simply use the terms "magnetic field" and "magnetic field strength" loosely.			
	(a)	(i)	The magnetic flux through a plane surface is the product of the flux density normal to the surface and the area of the surface.	B1
			Comments: Refer to definition in EMI lecture notes.	
		(ii)	$\phi_A = \phi_B$	B1
			Comments:	

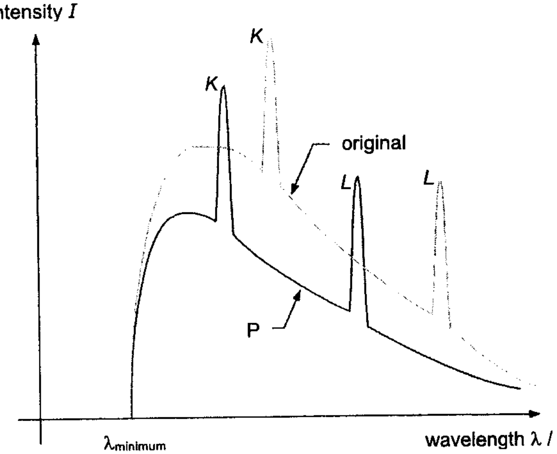
	As the magnetic flux (field lines) are confined within the iron core, the magnetic flux that passes through coils A, B and C are the same. Refer to EMI tutorial Q3 (modified from A-Level 2010/I/32).	
(iii)	Coil A, connected to AC source, produces a magnetic flux density that is varying with time sinusoidally. This results in a varying magnetic flux linkage through coil A and hence a varying magnetic flux linkage through coil B. By Faraday's law, an emf is induced in coil B due to changing magnetic flux linkages through coil B.	M1 A1
	Comments: There is a need to be clear which coil produces what and which coil experiences the change. Thus, a need to indicate Coil A which is producing the changing flux density. This is due to the alternating current passing through Coil A, and not due to the different number of turns in the coils.	
(iv)	$\frac{N_A}{N_B} = \frac{V_A}{V_B}$ $\frac{11}{6} = \frac{240}{V_B}$ $V_B = 131\text{ V}$	C1 A1
	Comments: The induced e.m.f. in coil B is the secondary voltage across coil B, which is dependent on the turns ratio. Voltage values are already in r.m.s.	
(b)	Since soft iron has a gap, the magnetic flux through coil C will be reduced and hence the rate of change of magnetic flux linkage through coil C will be lowered. By Faraday's law, induced emf in coil C is proportional to the rate of change of mangetic flux linkages, hence the maximum induced emf will be lower.	B1 B1
	Comments: The gap does not block the entire flux.	
(c)		

			[M1] for correct shape (positive cosine graph can only be in either the positive or negative axis). [A1] for correct label of ε_0 and T/4, 3T/4, 5T/4, 7T/4 (no values required).	
			Comments: Equation of a positive cosine graph is already provided by the question. The direction of the current could be "traced" based on the arrangement of the diodes which changes direction every half a period. Question also requires the graph to be labelled (although the calculated numerical values of peak induced e.m.f. and time intervals are not required).	

6	(a)	(i)	1.	$\text{energy} = 0-(-13.6) = 13.6 \text{ eV} = 13.6\times1.6\times10^{-19}$ $= 2.18\times10^{-18}$ J	B1
				Comments: Some student mistakenly use the energy value at n = 5 (or other n). To completely remove an electron, n = ∞ where energy = 0.	
			2.	The electron of the atom will <u>absorb 10.2 eV of energy</u> and be <u>excited to n = 2</u> level. (The incident electron will have 0.80 eV of energy left.)	B1
			3.	Nothing happens (No change). The <u>energy of the photon does not match any transition</u> (from ground state).	B1

			Comments: The question requires students to explain the possible result. Many did not indicate that 10.2 eV of energy is absorbed by the atom's electron for excitation by electron despite a value of 11.0 eV of the incident electron is provided. Some students were confused between the two mechanism of excitation: (1) high speed collision by another particle (incident electron in this question); (2) absorption of photon.	
		(ii)	$\Delta E = -0.849-(-13.6)$ $= 12.75$ eV $= 2.04\times10^{-18}$ J — C1 $\Delta E = \frac{hc}{\lambda}$ $\lambda = \frac{6.63\times10^{-34}(3.00\times10^{8})}{2.04\times10^{-18}}$ $= 9.75\times10^{-8}$ m or 97.5 nm — M1 (Accept f = 3.08 x 10^{15} Hz) <u>Ultraviolet</u> radiation will be emitted. — A1 (Do not accept UV.)	
			Comments: While many students were able relate this to de-excitation which emits a photon, some did not show clear working for calculation of wavelength or frequency of the photon despite required by the question. Some students mistakenly did not convert ΔE to Joules when substituting into the equation $\Delta E = hc/\lambda$. Only a handful of students managed to identify ultraviolet radiation emitted. Students are expected to know the ranges of wavelength or frequency for the EM spectrum.	
	(b)	(i)	$\frac{hc}{\lambda_{min}} = E_{k,\text{ initial}} = e(\Delta V)$ $E_k = 1.60\times10^{-19}(1.05\times1000) = 1.68\times10^{-14}$ J — C1 $\lambda_{min} = \frac{6.63\times10^{-34}(3.00\times10^{8})}{1.68\times10^{-14}}$ — C1 $= 1.18\times10^{-11}$ m — A1	
			Comments: A fair number of students were able to calculate the minimum wavelength.	

(ii)



[B1] Same $\lambda_{minimum}$, and lower intensity throughout.
[B1] Both peaks shift left

Comments:
The minimum wavelength is affected by the accelerating potential which remains the same for this question. Intensity is affected by the current in the filament (refer to Quantum tutorial Q7 & 8) and accelerating potential. Peaks are characteristics of the target metal. Metals with higher atomic number (more massive metals) have higher energy level transitions between the shells which implies shorter wavelengths of X-ray photons emitted (peaks).

7	(a)	(i)	progressive means there is energy transfer in the direction of travel of wave *(accept the lecture notes version)*	B1
			Comments: 80% got this correct.	
		(ii)	same or similar amplitude either unpolarised or polarised in the same plane	B1 B1
			Comments: 70% got both conditions correct.	

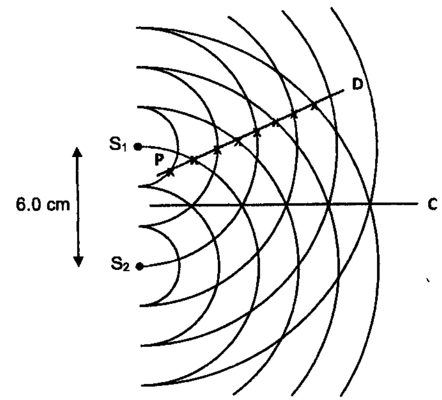
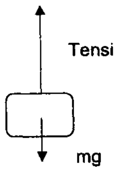


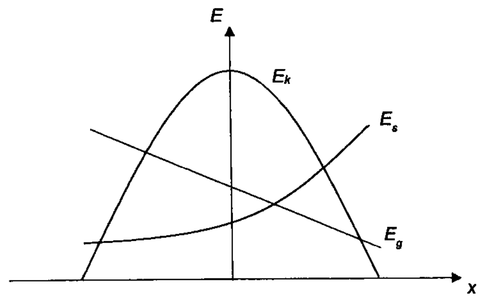
Fig. 7.1

		(iii)	line through 3 intersections where path difference is 0 and label C	B1
			Comments: 80% got this correct.	
		(iv)	point where path difference=1.5 λ and label P (any of the above) line through P and 3 other points and label D	B1 B1
			Comments: Only 30% got this correct. P must be shown as the intersection between a crest from one source and a trough—midway between two crests—from the other source.	
		(v)	$S_1S_2 = 3\lambda = 6.0$ cm B1 $\lambda = 2.0$ cm	

			Comments: 80% got this correct. Some left it blank.	
(b)	**(i)**		path difference $S_2P - S_1P = \sqrt{8.4^2 + 15^2} - \sqrt{2.4^2 + 15^2}$ M1 $= 2.0$ cm = one wavelength A1	
			Comments: Many students use the double-slit formula x = λD/a but this formula can only be used under the special condition where D >> a but this is not the case in this question, so it is wrong to use the double-slit formula in this question.	
	(ii)		path difference $= 1.5\lambda = 3.0$ cm	B1
			Comments: Few got this correct.	
	(iii)		$\sqrt{(OY+3)^2 + 15^2} - \sqrt{(OY-3)^2 + 15^2} = 3.0$ M1 $OY = 8.8$ cm A1	
			Comments: Very few got this correct. Many used the double-slit formula x = λD/a but as in (b)(i) this formula cannot used in this question.	
	(iv)		intensity at O due to 1 source $= \frac{P}{4\pi r^2} = \frac{20}{4\pi(0.03^2 + 0.15^2)}$ M1 = 68 W m^{-2} A0	
			Comments: About half got this correct.	
	(v)		$I \propto A^2$ at maxima, amplitude doubled so intensity = 4×68 = 272 W m^{-2}	B1
			Comments: Very few got this correct, most just add the two intensities.	
(c)	**(i)**		(antinode to antinode distance = $\frac{\lambda}{2} = \frac{2.0}{2} =$) 1.0 cm	B1
			Comments: Few got this correct.	
	(ii)		rate of fluctuations = $\frac{\text{speed of detector}}{\text{internodal distance}} = \frac{3.0 \text{ cm s}^{-1}}{1.0 \text{ cm}} = 3.0 \text{ s}^{-1}$	B1
			Comments: Some got this correct or have error carried forward.	

(d)	**(i)**		limiting angle of resolution $= \frac{\lambda}{b}$ $= \frac{500 \times 10^{-9}}{0.10}$ C1 $= 5.0 \times 10^{-6}$ rad A1	
			Comments: Most got this correct, some used 6.0 cm for b instead of 0.10 m.	
	(ii)		angle of separation of sources $\approx \frac{6.0 \times 10^{-2}}{15 \times 10^{3}} = 4.0 \times 10^{-6}$ rad	B1
			Comments: About half got this correct.	
	(iii)		angle of separation of sources < limiting angle of resolution, so cannot resolve	B1
			Comments: About half got this correct or have error carried forward.	

8	(a)		Since the spring constant k and the mass m are both constant, The acceleration of the mass is proportional to the displacement from the equilibrium position	B1
			and the negative sign indicates that the acceleration and displacement are in opposite directions / acceleration is towards the equilibrium.	B1
			Hence the oscillation is simple harmonic.	
			Comments: 1. You must say that k and m are constants. 2. You must say that the negative sign indicates the opposite direction. 3. Just saying "$a = -\frac{k}{m}x$ shows that a and x are proportional in opposite directions" will not be credited.	
	(b)	(i)	$\omega^2 = \frac{k}{m}$ C1 $(2\pi f)^2 = \frac{35000}{0.020}$ M1 $f = 210.5 = 210$ Hz A1	
			Comments: Almost everyone got this correct.	
		(ii)	$F_{max} = ma_{max}$ $= m\omega^2 x_0$ $= (0.020)(2\pi(210))^2(2\times10^{-4})$ M1 $= 6.96 = 7.0$ N A1	
			Comments: 1. Those who wrote $F_{net} = kx$ were given the benefit of the doubt, but only if the answer was correct.	
		(iii)	The maximum tension in the spring occurs when the magnet is at the bottom of the oscillation  $F_{net} = T - mg$ $T = F_{net} + mg$ $T = 7.0 + 0.020 \times 9.81$ M1 $= 7.2$ N A1	

			Zero marks if the weight of the mass was neglected.	
			Comments: 1. Numerous mathematical errors here.	
		(iv)	$E_{kmax} = \frac{1}{2}m\omega^2 x_0^2$ $= (0.5)(0.020)(2\pi(210))^2(2\times10^{-4})^2$ M1 $= 7.0\times10^{-4}$ J A1	
			Comments: 1. So many students forgot to square the velocity, or one of the other variables. 2. It is wrong to say that max KE = max EPE since EPE is not zero when the mass is at the equilibrium point, and there is also the effect of GPE.	
		(v)	 An inverted parabola for kinetic energy [B1] An upward curve to the right for elastic potential energy [B1] A straight line with negative gradient to the right for gravitational potential energy [B1]	
			Comments: 1. The spring is always extended so E_s is never zero. 2. Downwards is positive so E_g is sloping down to the right. 3. E_g is a straight line. 4. E_k parabola must touch the x axis.	
	(c)	(i)	The frequency of the alternating current is 210 Hz. This is because when the external driving frequency is equal to the natural frequency of the magnet and spring,	B1
			resonance occurs, and maximum power transfer to the oscillation.	B1

			The oscillation will have the <u>largest amplitude</u> and the speaker will <u>produce the loudest sound</u>.	
			Comments: 1. You must mention that the driving and natural frequencies are equal, resonance occurs 2. And also mention that this is when maximum amplitude / maximum energy transfer occurs.	
		(ii)	The paper cone and magnet experience air resistance / resistive forces when oscillating which produces <u>light damping</u>. *(Any answers which refer to the electromagnetic induction will not be accepted as the circuit is open)*	B1
			Thus without the external periodic force, the <u>amplitude of the oscillation will decay gradually with time.</u>	B1
			Comments: 1. This question is about <u>damping</u> and <u>amplitude</u>. 2. You must state that damping occurs due to air resistance / resistive forces. 3. And that the amplitude slowly decreases with time. 4. The circuit is not connected so the solenoid is irrelevant. 5. Answers which related to energy being lost are only credited if they refer to resistive forces.	
		(iii)	When the mass of the loudspeaker increases, the <u>natural frequency of the system decreases since</u> $2\pi f = \sqrt{\frac{k}{m}}$.	B1
			Therefore, the (driving) <u>frequency at which the peak amplitude occurs will decrease.</u>	B1
			Comments: 1. It is wrong to say that acceleration will decrease. (Acceleration in a harmonic motion is always increasing and decreasing, it will not have a constant value). 2. It is wrong to say that the additional mass causes damping. Friction causes damping, not mass. 3. It is wrong to say that mass causes amplitude to increase. Mass and amplitude have no relationship. 4. It is wrong to say that the magnet is closer to the solenoid thus causing the frequency to change. The distance to the solenoid does not affect the frequency. 5. It is wrong to say that the amplitude changes so the frequency changes. The amplitude and frequency has no relationship. A sound can be high pitched and loud, high pitched and soft, or low pitch and loud, or low pitch and soft.	

		(iv)	Different speakers of different mass would have <u>different resonant frequencies</u>. or The <u>largest speakers would be heavier and have lower resonant frequencies</u> and the <u>smallest speakers would be lighter and have higher resonant frequencies</u>. or This will allow the loudspeaker box to <u>better produce sounds at different frequencies</u> for broadcasting music or voices. (Any of the above)	B1
			Comments: 1. This was very poorly done. 2. Having multiple speakers does not mean there will be interference pattern. Interference only occurs when the waves are coherent, meaning they have the same frequency. It's not relevant for this question. 3. Having multiple speakers doesn't mean the sound will be louder. It's not the number of speakers that's important but the fact that they have different sizes. Why are the speakers different sizes? 4. Once again, loudness and pitch are not related. 5. It's wrong to say that having speakers of different sizes allows sounds of different volume to be played. It is not true that "large speakers have loud sounds while small speakers have soft sounds". 6. Different countries having different frequencies of alternating current is not relevant to the question. The alternating current power supply is not plugged directly into the speaker. Thus, Japan having 50Hz supply and Singapore having 60Hz supply doesn't mean that music would sound different in Japan compared to Singapore.	

TAMPINES MERIDIAN JUNIOR COLLEGE

JC2 PRELIMINARY EXAMINATION

CANDIDATE NAME	
CIVICS GROUP	

H2 Physics **9749/04**

Paper 4 Practical

25 August 2022

2 hours 30 minutes

Candidates answer on the Question Paper.
No Additional Materials are required.

READ THESE INSTRUCTIONS FIRST

Write your name, class and index number in the spaces at the top of this page, page **11** and **17**.
Write in dark blue or black pen on both sides of the paper.
You may use an HB pencil for any diagrams, graphs or rough working.
Do not use staples, paper clips, glue or correction fluid.

Answer **ALL** the questions.

You are allowed 1 hour to answer Questions 1 and 2; and you are allowed another 1 hour to answer Question 3.

Question 4 is a question on the planning of an investigation and does not require apparatus.

Write your answers in the space provided in the question paper. The use of an approved scientific calculator is expected, where appropriate. You may lose marks if you do not show your working or if you do not use appropriate units.

Give details of the practical shift and laboratory where appropriate in the boxes provided.

The number of marks is given in brackets [ ] at the end of each question or part question.

Shift
Laboratory

For Examiner's Use	
1	/10
2	/13
3	/20
4	/12
Total	/55

This document consists of **18** printed pages and **2** blank pages.

1 The resistance of a light-dependent resistor (LDR) changes when it is illuminated with light of different intensities.

In this question, you will investigate how the light detected by a LDR depends on the thickness of an absorber.

(a) **(i)** Connect the circuit shown in Fig. 1.1. The light-emitting diode (LED), which is soldered (attached) to the 200 Ω resistor, should be connected the right way round so that light is emitted.

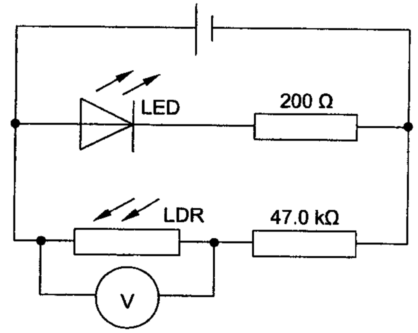


Fig. 1.1

(ii) You are provided with a black straw of approximate length of 4 cm.

(iii) Use the straw and clear adhesive tape to make a cylinder that fits neatly over the LDR and LED.

Cut the cylinder into two halves of approximately 2 cm each and fit the 2 cylinders over the LDR and LED, as shown in Fig. 1.2.

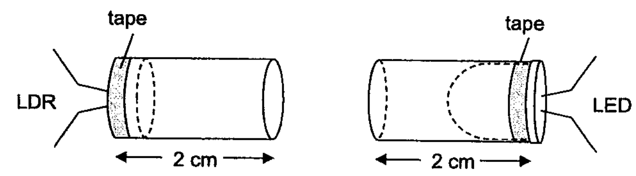


Fig. 1.2

BP-679

(b) Place the cylinders together, as shown in Fig. 1.3.

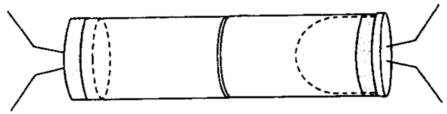


Fig. 1.3

Record the voltmeter reading V_0.

V_0 = .. 0.28 V .... [1]

[1] Accept up to 3.00 V (cannot be negative)
Correct d.p and units

(c) Fold the sheet of tracing paper in half four times so that you have 16 layers.

Using a micrometer screw gauge, determine the thickness of one layer of tracing paper.

zero error = 0.00 mm
For 16 pieces of paper,
d_1 = 1.00 mm
d_2 = 0.97 mm
$\langle d \rangle$ 0.99 mm

Thickness of one piece of paper = 0.99/16 = 0.062 mm

[1] Recording zero error.
Repeated readings of thickness$_{16}$.
Correct d.p. Accepted range: 0.5 mm to 2.5 mm

[1] Correct calculation of thickness with correct s.f. and units.

[-2] measuring thickness of less than 16 pieces of paper.

thickness of one layer = .. 0.062 mm .... [2]

(d) **(i)** Place four layers of tracing paper between the LED and the LDR as shown in Fig. 1.4.

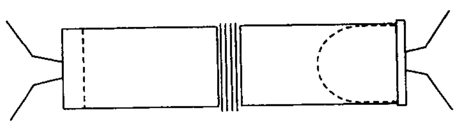


Fig. 1.4

Record the voltmeter reading V.

V = .. 1.29 V ....

(ii) Repeat **(d)(i)** using eight layers of tracing paper.

V = 2.15 V .... [1]

[1] Correct d.p and units
$V_o < V(di) < V(dii)$

(e) Comment on the trend of your results.

The voltmeter reading increases with the increase in the number of layers of paper.
[B1, allow ecf according to trend of (b) and (d)]
[if no trend, no ecf]
[cannot accept proportional or other overly specific trends] [1]

(f) **(i)** State and explain **one** significant source of error or limitation of the procedures for this experiment.

Any of the following that affects voltmeter reading, [B1]
- 2 readings not enough to draw a conclusion
- Alignment of LDR and LED (not sufficient to just mention alignment of cylinder)
- Stray light coming in because the cylinders are not sealed / external light hits LDR
- Difficult to hold all together therefore voltage reading fluctuates
- Separation between LED and LDR changes as paper is added. [1]

(ii) Suggest **one** improvement that could be made to the experiment to address the error or limitation identified in **(f)(i)**. You may suggest the use of other apparatus or a different procedure.

Corresponding improvements [B1]
- Collect six sets of readings and plot a graph to determine whether the average drop of intensity per layer is consistent.
- Guide used / line on desk / adjust LED/LDR to get max voltage / method of fixing LED/LDR in cylinder
- Dark room / black cloth over / lights off and curtains drawn / black box / black tape [1]
- Method of fixing. Eg, clamp/plasticine / tape
- Pre-slots in tube

(g) Suggest changes that could be made to the experiment to investigate how the light detected by a LDR depends on the angle between the polarising axes of a pair of polarising filters.

You may assume that a pair of **unmarked** polarising filters is available.

You may draw a diagram to show how the apparatus would be arranged.

- Repeat steps **(ai)** but replace the tracing paper with <u>2 polarising filters</u> [B1]
  Note: The setup here should be based on the set up in (a) and only essential changes are made.
- Mark the axis where the polarizing filters give <u>the minimum V</u> reading. Polarising axes of the 2 polarisers are <u>parallel</u> at this angle. (also accept max V corresponding to 2 polarising axes are perpendicular) [B1]
- <u>Vary angle</u> between polarizing axes and measure the angle with a <u>protractor</u> and <u>measure potential difference using voltmeter</u>. [B1]

....

.... [3]

[Total: 10 marks]

2 In this experiment you will investigate how the motion of a metre rule depends on the length of the string loops used to suspend it.

(a) Measure and record the width w of one of the metre rules, as shown in Fig. 2.1.

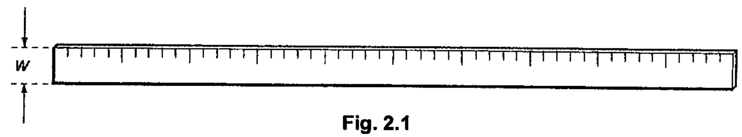


Fig. 2.1

$$w = \frac{2.6 + 2.6}{2} = 2.6 \text{ cm}$$

[1] Repeated readings
Correct d.p. and units
$2.0 \le w \le 3.0$ cm

w = ... 2.6 cm .... [1]

(b) **(i)** Select the two longer pieces of string.

(ii) Tie the ends of one piece of string to make a loop.

(iii) Measure and record the length l of this loop, as shown in Fig. 2.2.

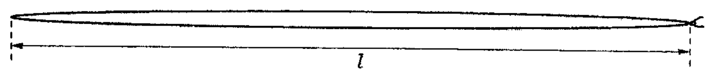


Fig. 2.2

$$l = \frac{48.0 + 47.9}{2} = 48.0 \text{ cm}$$

[1] Repeated readings
Correct d.p. and units
40 cm $\le l \le$ 50 cm

l = ... 48.0 cm .... [1]

(iv) Repeat **(ii)** with the other long piece of string.

The length of this loop should be the same as that in **(iii)**.

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(c) (i) Use the stands to set up the two metre rules and the two loops of string as shown in Fig. 2.3.

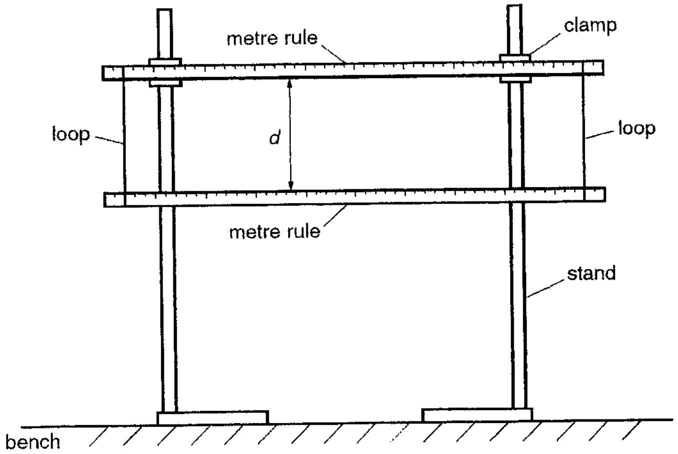

Fig. 2.3

The rules should be horizontal with the scale markings facing you.

The loops should be vertical, parallel to each other and placed at the 5 cm and 95 cm marks on both rules.

(ii) Using your values in **(a)** and **(b)(iii)**, determine the distance d using the relationship

$$d = l - 2w.$$

$d = l - 2w = 48.0 - 2(2.6) = 42.8$ cm

[1] Correct calculation
Correct d.p. and units

d = ... 42.8 cm .... [1]

(iii) Estimate the percentage uncertainty in your value of d.

$\Delta d = \Delta l + 2\Delta w = 0.2 + 2(0.2) = 0.6$ cm

% uncertainty $= \frac{0.6}{42.8} \times 100\% = 1.4\%$

[1] $0.2 \text{ cm} \le \Delta l \le 0.5$ cm ; $0.2 \text{ cm} \le \Delta w \le 0.5$ cm
Same precision
Correct calculation
Correct s.f

1.4 % .... [1]

(d) Move the left end of the bottom rule towards you and the right end away from you. Release the rule and watch the movement.

The left end of the rule will move away from you and back towards you, completing a swing. The time taken for one complete swing is T.

By timing several of these complete swings, determine an accurate value for T.

No. of oscillations, $N = 20$
$t_1 = 17.7$ s, $t_2 = 17.5$ s, $t_{ave} = 17.6$ s
$T = \frac{t_{ave}}{N} = \frac{17.6}{20} = 0.880$ s (3 s.f.)

[1] Repeated reading with t ≥ 10.0 s and 1 d.p.

[1] No of oscillations N recorded; and
T correctly calculated to correct s.f. and unit
$0.3 \text{ s} < T < 1.5$ s

T = .. 0.880 s .... [2]

(e) Repeat **(b)**, **(c)(i)**, **(c)(ii)** and **(d)** for the shorter lengths of string.

$l_{short} = \frac{23.4 + 23.3}{2} = 23.4$ cm

$d_{short} = l_{short} - 2w = 23.4 - 2(2.6) = 18.2$ cm

No. of oscillations, $N = 20$
$t_1 = 11.7$ s, $t_2 = 11.7$ s, $t_{ave} = 11.7$ s
$T = \frac{t_{ave}}{N} = \frac{11.7}{20} = 0.585$ s (3 s.f.)

T = .. 0.585 s .... [3]

[1] Repeated readings
Correct d.p. and units
$15 \text{ cm} \le l_{short} \le 25$ cm

[1] Repeated reading with t ≥ 10.0 s and 1 d.p.
No of oscillations N recorded; and
T correctly calculated to correct s.f. and unit

[1] Second value of T < first value of T

(f) It is suggested that the relationship between T and d is

$$T^2 = kd$$

where k is a constant.

(i) Using your data, calculate two values of k.

$$k = \frac{T^2}{d}$$

$$k_1 = \frac{0.880^2}{42.8} = 0.0181\ \text{s}^2\ \text{cm}^{-1}$$

$$k_2 = \frac{0.585^2}{18.2} = 0.0188\ \text{s}^2\ \text{cm}^{-1}$$

[1] Both k values calculated correctly
Correct s.f. and units

ue for k = 0.0181 $\text{s}^2\ \text{cm}^{-1}$

second value for k = 0.0188 $\text{s}^2\ \text{cm}^{-1}$ [1]

(ii) Justify the number of significant figures that you have given for your values of k.

(Significant figures of) k follows the least significant figures of T (or t) and d.
(or least s.f. plus 1) [B1]

If (c)(i) answer plus 1 sf, c(ii) answer must mention plus 1 sf.
Not accepted: follow least s.f. of *raw data* (generic statement)

[1]

(iii) State whether the results of your experiment support the suggested relationship. Justify your conclusion by referring to your answer in **(c)(iii)**.

Percentage difference in $k = \frac{k_2 - k_1}{k_1} \times 100\%$

$= \frac{0.0188 - 0.0181}{0.0181} \times 100\%$

$= 3.87\%$

[1] % difference of k calculated correctly (no need to mark for sf)

Since percentage difference of k values is 3.87% which is greater than the percentage c(iii) of 1.4%, the results of the experiment do not support the suggested relationship.

[1] k percentage difference compared with percentage error and make correct conclusion [2]

[Total: 13 marks]

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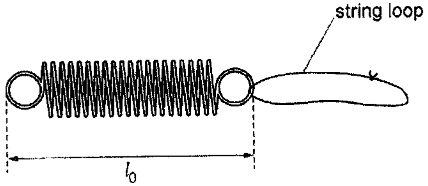
Candidate Name: ____________________ **Civics Group:** __________

3 In this experiment, you will apply several forces to a metre rule.

(a) Measure and record the length l_0 of the unstretched spring, as shown in Fig. 3.1. Use a metre rule for this measurement.



$l_0 = \frac{5.2+5.2}{2} = 5.2$ cm

[1] Repeated readings, correct d.p. and units
4.5 cm ≤ l_0 ≤ 6.5 cm
Use of vernier caliper not accepted.

l_0 = 5.2 cm .... [1]

(b) One of the metre rules has a rubber band wrapped around its centre. Record the distance L from one end of the metre rule to the rubber band, as shown in Fig. 3.2.

Do not adjust the position of the rubber band throughout the experiment.

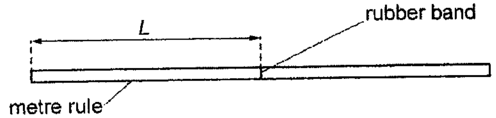


Fig. 3.2

L = 0.500 m ....

(c) Measure and record the diameter d of one of the slotted masses, as shown in Fig. 3.3. Use a vernier caliper for this measurement.

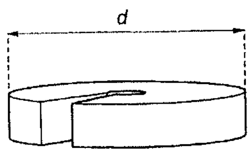


Fig. 3.3

There is no zero error.
d_1 = 3.74 cm; d_2 = 3.74 cm

$d = \frac{3.74+3.74}{2} = 3.74$ cm

[1] Check zero error

[1] Repeated readings;
Correct d.p. and units
3.50 cm ≤ d ≤ 4.50 cm

d = 3.74 cm .... [2]

(d) (i) Set up the apparatus as shown in Fig. 3.4.

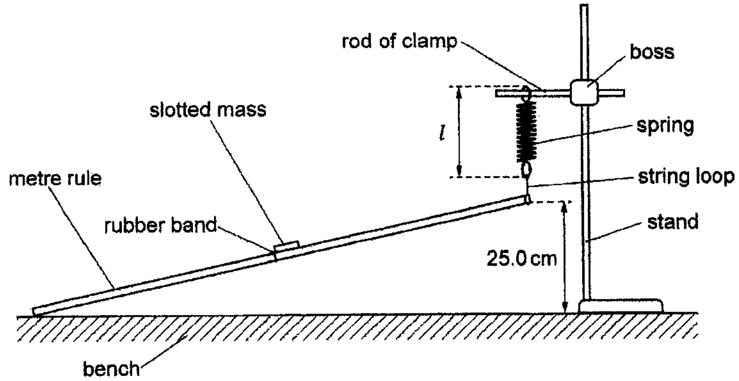


Fig. 3.4

One of the slotted masses should be placed on the metre rule and be resting against the rubber band.

(ii) Adjust the apparatus so that the bottom edge of the raised end of the metre rule is 25.0 cm above the bench and the spring is vertical.

Measure and record the length l of the stretched spring.

$l = \frac{8.7+8.7}{2} = 8.7$ cm

l = 8.7 cm ....

(iii) Calculate e where $e = l - l_0$.

$e = 8.7 - 5.2 = 3.5$ cm

[1] Repeated l;
Correct calculated value of e;
Correct d.p. and units of e and l

e = 3.5 cm .... [1]

(e) Place a second mass next to the first mass, as shown in Fig. 3.5.

Repeat **(d)(ii)** and **(d)(iii)**.

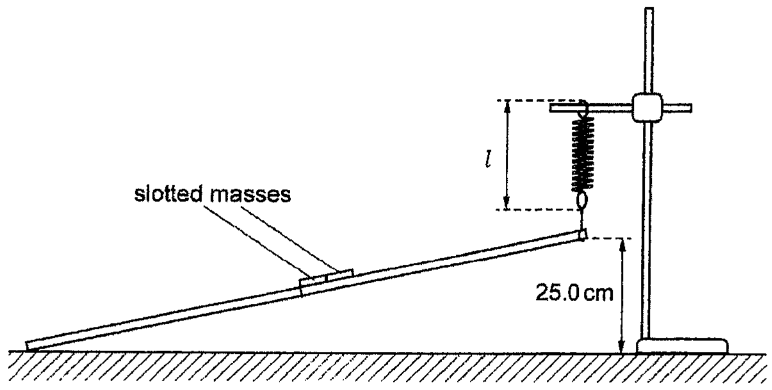


Fig. 3.5

$l = \frac{11.2 + 11.2}{2} = 11.2$ cm

$e = 11.2 - 5.2 = 6.0$ cm

$l =$ 11.2 cm ....

$e =$ 6.0 cm ....

(f) **(i)** Add further slotted masses next to the masses already on the metre rule.

Repeat **(d)(ii)** and **(d)(iii)** for each additional mass.

For each set of measurements, record the value of *n* where *n* is the number of slotted masses on the rule.

n	l_1 / cm	l_2 / cm	l_{avg} / cm	e / cm
1	8.7	8.7	8.7	3.5
2	11.1	11.2	11.2	6.0
3	13.9	14.0	14.0	8.8
4	16.6	16.7	16.7	11.5
5	19.6	19.5	19.6	14.4
6	22.8	22.9	22.9	17.7
7	26.3	26.3	26.3	21.1

[1] 7 sets of data, including (d) and (e), correct trend (if n= 0 included, not acceptable)
[1] Correct headers with units
[1] Correct d.p. of *l*, with repeat
[1] Correct calculated values and d.p. of *e*

[4]

(ii) Plot a graph of *e* against *n*. Draw a curve through your points. [3]

(iii) Draw a tangent to the curve at $n = 3$. [1]

(iv) Determine the gradient *G* of the tangent.

$G = \frac{19.8 - 3.0}{7.0 - 1.0} = 2.8$

[1] Correct read-off and calculation;
Correct s.f. (least s.f. of *l* or +1)

(No unit required for gradient; accept cm as unit zero mark if wrong unit stated)

$G =$ 2.8 .... [1]

(g) State with justification if there are any anomalous data or result that you may have obtained.

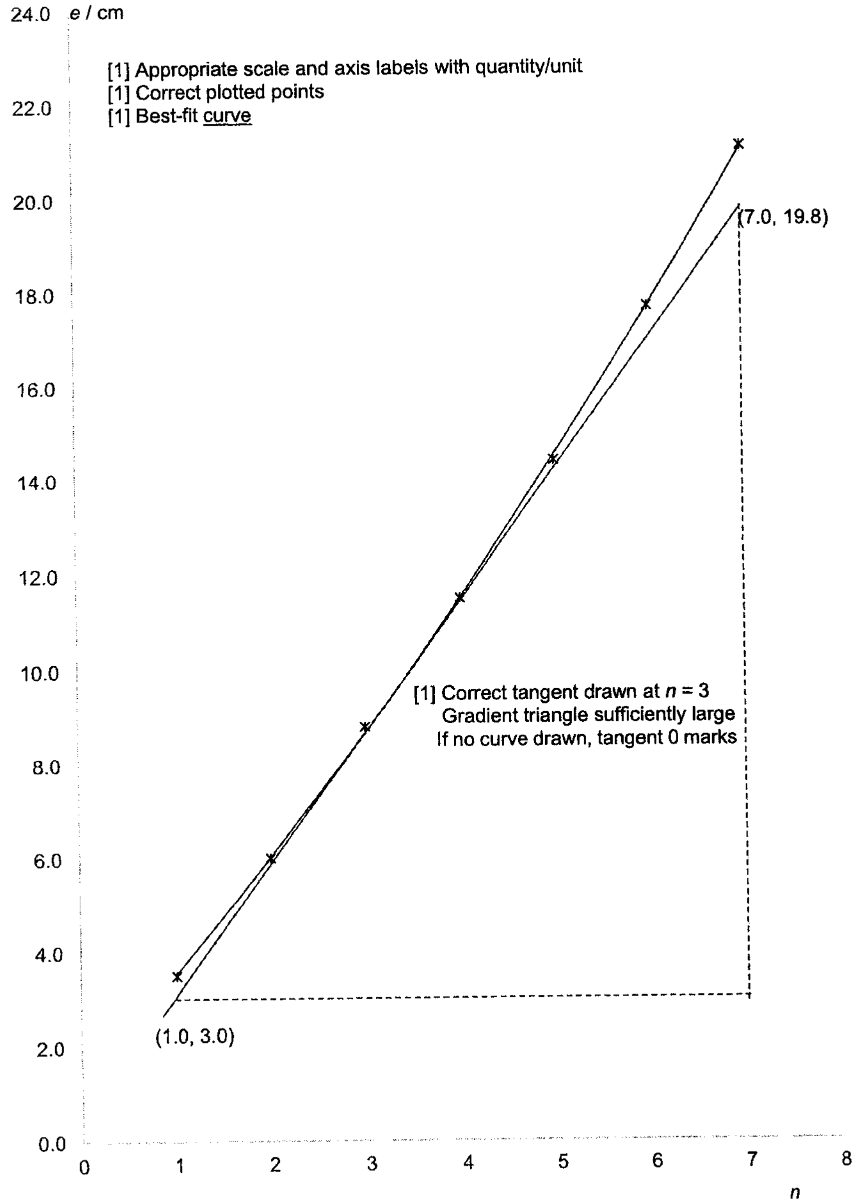
There is no anomalous data present as there are no data points which deviate significantly from the trend of the plotted points. [1]

OR

The point (,   ) is anomalous as it deviates significantly from the trend presented by the rest of the plotted points. [1]

.... [1]

BP~685



[1] Appropriate scale and axis labels with quantity/unit
[1] Correct plotted points
[1] Best-fit <u>curve</u>

[1] Correct tangent drawn at $n = 3$
Gradient triangle sufficiently large
If no curve drawn, tangent 0 marks

(h) **(i)** Use the Newton meter to determine the weight W of one slotted mass.

$$W = \frac{1.0 + 1.0}{2} = 1.0 \text{ N}$$

[1] Repeated readings;
Correct d.p. and units
$0.8 \text{ N} \le W \le 1.2 \text{ N}$

$W =$ 1.0 N .... [1]

(ii) G and n are related by the expression

$$G = \frac{W}{2kL}(dn + L)$$

where k is the spring constant of the spring and $n = 3$.

Calculate k.

$$G = \frac{W}{2kL}(dn + L)$$

$$2.8 \times 10^{-2} = \frac{1.0}{2k(0.500)}\left[3.74 \times 10^{-2}(3) + 0.500\right]$$

$k = 22 \text{ N m}^{-1} (= 0.22 \text{ N cm}^{-1})$

[M1] Substitution (in correct units)
[A1] k correctly calculated (-1 if negative)
[B1] Correct s.f. and unit

$k =$ 22 N m^{-1} .... [3]

(iii) The experiment is repeated with two **identical** springs of k value obtained from **h(ii)**. The springs are connected as shown in Fig. 3.6.

Fig. 3.6

State and explain the effect on G.

Effective spring constant is <u>halved</u> (since springs are in series arrangement). [B1] ......

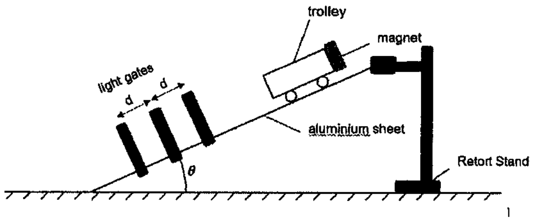
G will be <u>doubled</u>. [B1] ......

(deduct 1 mark if use "decrease/increase" respectively) [2]

[Total: 20 marks]

Candidate Name: ______________________ **Civics Group:** __________

4

Annotation	Rubrics	Max	Actual
Diagram	**D1**: Labelled diagram showing • aluminium sheet supported by stand or some means • workable setup to measure velocity at the end of the ramp (e.g. a pair of light gates connected to datalogger or video camera with ruler in the frame, or any other workable setup, or inferred from text with details)  Do not accept if setup is not likely to be workable. The support (retort stand etc) must be shown to be awarded the mark.		
Basic Procedure	**BP1**: Measure velocity to obtain 6 sets of data for each part: Part 1: keep angle of slope θ constant, vary magnetic flux density B Part 2: keep magnetic flux density B constant, vary angle of slope θ	1	
Control	**C1**: Keep the total mass of the trolley and magnet constant by adding / removing masses as required and measuring using an electronic balance.	1	

Measurements	**M1**: Method to vary and measure θ, by adjusting the stand/jack and e.g. use protractor Or determine θ by calculation, e.g. use a rule(r) to measure two appropriate distances to use in a trigonometrical ratio. **M2**: Method to vary and measure *B* using a (calibrated) Hall probe (or teslameter / gaussmeter) and vary B by using different magnets. (Name of the instrument must be stated) **M3**: Measure v using appropriate use of light gates with data logger or using a video camera with frame by frame playback to determine distance and time to calculate the speed of the object, or measure the distance using metre rule and time using stopwatch. Velocity is calculated as $v = \frac{d}{t}$ (if not directly measured) Ultrasonic distance sensor, speedometer, speed sensor, radar chronometer, accelerometer are usually not found in Cambridge answers and therefore not accepted.	3	
Analysis of data	**A1**: Plot a suitable graph of lg v_T vs lg B (keeping θ constant) a straight line graph of gradient = *q* is obtained. <vertical intercept = lg(*k*) + *p* lg sinθ) *not required*> **A2**: Plot a suitable graph of lg v_T vs lg sinθ (keeping B constant), a straight line graph of gradient = *p* is obtained <[vertical intercept = lg(*k*) + *q* lg B] *not required*>	2	
Other (Reliability)	**R1**: Method to ensure terminal velocity is obtained, such as: • or measure using 2 pairs of light gates attached with data loggers to compare the speeds at 2 sections of the journey • or other means such as plotting velocity-time graph to find the velocity asymptote, or use video frame by frame to compare time for example every 1 cm of the motion near the end of the slope. • (If terminal velocity is not achieved, take measures such as extend the runway.) **R2:** Repeated reading of velocity and take average to reduce random error. (do not accept "for greater accuracy and reliability") **R3**: Methods to obtain reliable measurement of B such as: • adjust probe until maximum value • or measure B using Hall probe first in one direction, then in the opposite direction and average, • or ensure that measurement of B is taken at the same distance from the magnet using vernier calipers • or ensure B is always taken at the surface of aluminium sheet. • or other valid methods.	3	

BP~687

	R4: Preliminary readings to ensure that there are significant changes to terminal velocity when the independent variables are varied. If not, steps taken to rectify such as • adjust the magnet distance from the sheet, • adjust strength of magnets, • adjust mass of the trolley, • adjust maximum angle of inclination of the ramp • or other valid method. Accept Preliminary readings for maximum flux density of magnet and min angle of slope such that the trolley can reach the bottom of the slope. (discussion must include both factors to be awarded.) **R5**: Any other reasonable measures to improve accuracy or precision. Measures that do not significantly affect the experiment, such as "turn off the fans", are considered trivial and will not be awarded credit.		
Safety precaution	**S1**: Method to stop the trolley once the trolley passes X, e.g. place a block / stop on the bench near the end of the sheet so that trolley will not cause injury. **S2**: Ensure the path of the trolley is clear of obstruction such as fingers, so that the trolley does not cause injury upon impact. **S3**: Any other reasonable safety measure. A safety measure of "wearing covered footwear" is taken as a given, and as such does not gain additional credit (You would not be allowed into the lab wearing slippers in the first place). Wearing gloves and goggles is an unrealistic safety measure for this experiment. The aluminium plate is not expected to heat up significantly from the motion of the trolley. The main safety hazard comes from the speeding trolley, hence safety measures should focus on that.	1	

Markers' Comments for Planning:

Many candidates are not precise in their statements as they do not satisfy the requirements of the mark scheme to be awarded credit.
These include

1. not stating the instrument used for measuring the quantity.
2. not saying how a variable is changed, example B is changed by using different magnets
3. not saying how mass will be kept constant, it cannot be kept constant by measuring it.
4. Not giving science related reasons such as reduction of random errors for taking average of values.
5. Not mentioning how to ensure terminal velocity.

Not accepted in the mark scheme:
Ensure no other magnets or current carrying conductors around to disrupt magnetic flux B. (static magnetic sources such as earth's magnetic field have no effect on EMI).
Tape magnet securely (trivial).
Mark a point at the start of the trolley. (does not affect terminal velocity)
Clamp retort stand.

Diagram

[Total: 12 marks]

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