PHYSICS

9749

SUGGESTED MARK SCHEME
Maximum Mark: 190

October/November 2019

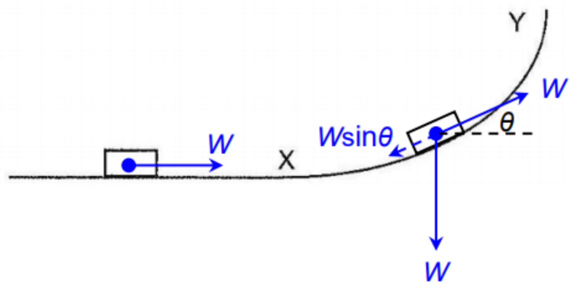
Paper 1
Multiple Choice

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

Notes:
Q5, 13, 23, 24 and questions on parallel D.C. circuits were not well done.

Question 5
As the total momentum of the system is zero before the explosion, the centre of gravity cannot move throughout. If it does, this would mean that an external resultant force must have been applied to the system.

Question 8
Those who incorrectly selected option A thought that KE was dropping, and missed out on the fact that there was a force exerted to the body continually.



Since $\Delta KE = F_{net}\Delta x$, the rate of increase of KE (with respect to distance) depends on F_{net}. (In fact, the gradient of the graph is equal to F_{net}.)

If the object was being moved along a horizontal frictionless surface, F_{net} would simply be W and constant. So option B would have been the answer.

In this question however, as the slope becomes steeper, the net force acting on the block becomes smaller. This is because the component of weight along the slope increases as the slope angle θ increases, and $F_{net} = W - W\sin\theta$. In fact, when the slope is completely vertical, the force applied will be completely balanced by the weight, and the KE of the object will stop increasing.

Question 13

Those who chose option **A** (43 m s^{-1}) did not convert the mass of the helium into kilograms.
Since the r.m.s. speed of a typical air molecule is about 500 m s^{-1}, a helium atom with the same KE but smaller mass should have a higher speed.

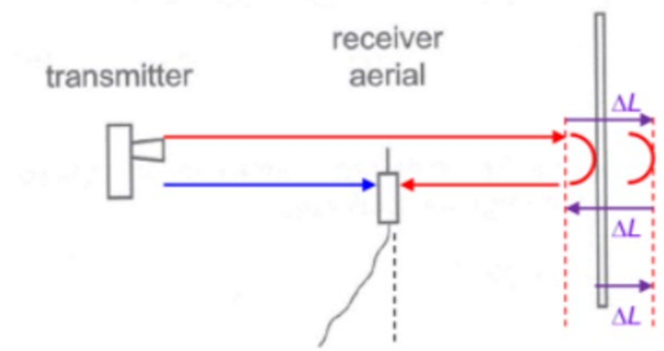
Question 15

Those who chose option **C** did not consider the direction of heat transfer.

Question 17

Option **A** - the times of minimum **and** maximum disturbance
Option **C** – the times of maximum disturbance

Question 18



when metal is shifted by ΔL , the red path increases by $2\Delta L$.

To get from one constructive to another,

- $\Delta L = 60$ mm
- Δpath = red – blue = 1λ

Question 21

A charged particle in a uniform electric field undergoes constant acceleration, and the gradient of the v-t graph is constant.

Question 23

Possible misconception – if two components are connected in parallel and one of them is not conducting, then the other will not conduct.

Question 24

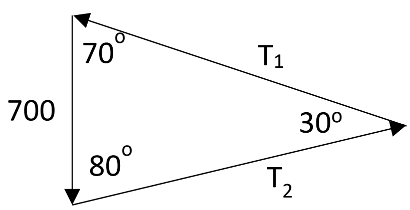
Those who chose **C** did not realise that when the value of the variable resistor is 0, the resistance of the left-hand side of the circuit is 0, not 1000 Ω.

Paper 2
Structured Questions

Notes:
Singaporean candidates have to be good at the maths and the presentation of maths.

Weaker answers often did not make use of scientific terms appropriately. Weaker answers for definitions were often imprecise.

Better answers tend to be short and direct.

Qns		Marks
1(a)	resultant force (in any direction) is zero	**B1**
	resultant torque/moment (about any point) on the body is zero	**B1**
	Notes: must refer to resultant/net/sum of…	
1(b)	sum of forces along vertical:	
	$T_1 \sin 20° + T_2 \sin 10° - 700 = 0$	**M1**
	sum of forces along horizontal:	
	$T_1 \cos 20° - T_2 \cos 10° = 0$	**M1**
	solving simultaneously	
	$T_1 = 1400$ N	**A1**
	$T_2 = 1300$ N	**A1**
	OR	
		
	$\dfrac{T_1}{\sin 80°} = \dfrac{700}{\sin 30°}$	**(M1)**
	$T_1 = 1400N$	**(A1)**
	$\dfrac{T_2}{\sin 70°} = \dfrac{700}{\sin 30°}$	**(M1)**
	$T_2 = 1300N$	**(A1)**
1(c)	let angle that T makes with pole be θ	
	$\tan\theta = \dfrac{1.6}{1.2}$	
	$\theta = 53.1°$	**B1**
	take moments about base of pole, sum of clockwise moments = sum anti-clockwise moments	
	$1.2(T \sin 53.1°) = (1.2 + 0.60)(150)(\cos(10°))$	**M1**
	$T = 280$ N	**A1**
2(a)(i)	oscillations perpendicular to the direction of energy transfer	**B1**

Qns **Marks**

visible light / mechanical waves in string under tension etc **B1**

Notes: use words like vibrations/oscillations

2(a)(ii) Wave's oscillations are made to occur in one direction, in a plane normal to the direction of energy transfer. **B1**

2(b)(i) intensity after 1st filter $= I_0 \cos^2(30°)$ **C1**

$$I_T = \left[I_0 \cos^2(30°)\right]\cos^2(60° - 30°)$$ **C1**

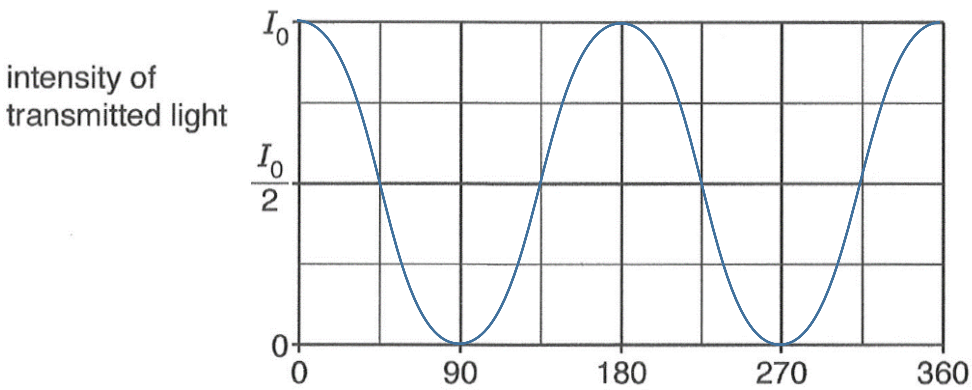
$$= I_0 \cos^4(30°)$$

$$= 0.56 I_0$$ **A1**

2(b)(ii) intensity is directly proportional to square of amplitude, $I \propto A^2$ **M1**

$$\frac{A_T}{A_0} = \sqrt{\frac{I_T}{I_0}} = \sqrt{\frac{0.56 I_0}{I_0}} = 0.75$$ **A1**

2(b)(iii)



B1 – shape of cosine-squared

B1 – passes through important points such as $\frac{I_0}{2}$ at 45°, 135°, 225°, 315°

2(c)(i) sound waves are longitudinal where oscillations of air particles are parallel to direction of energy transfer **B1**

2(c)(ii) period $T = \frac{1}{f} = \frac{1}{740}$ **C1**

6.8 cm represents $\frac{1}{740}$ s; **C1**

1 cm represents $\frac{1}{740} \div 6.8 \text{ s cm}^{-1}$

$= 0.20 \text{ ms cm}^{-1}$ **A1**

3(a) work done per unit positive charge in moving a small positive test charge from infinity to that point **B1**

Qns		Marks
3(b)(i)	$r = 1.0 \times 10^{-10}$ m, $V = 780$ V	B1
	$$V = \frac{Q}{4\pi\varepsilon_0 r} = \frac{ne}{4\pi\varepsilon_0 r}$$ $$n = \frac{4\pi\varepsilon_0 rV}{e}$$ $$= \frac{4\pi\left(8.85\times10^{-12}\right)\left(1.0\times10^{-10}\right)(780)}{1.60\times10^{-19}}$$ $$= 54.2$$	C1
	1 proton has a positive charge of +*e*. As charge in nuclear is 54*e*, it has 54 protons.	A1
	Notes: examiners required full substitution	
3(b)(ii)	distance between proton and centre of nucleus much larger than proton radius and nuclear radius	B1
	Notes: precision of terms required. “size” was not accepted; use “radius”/”diameter”	
3(b)(iii)	$$F = ma$$ $$a = \frac{F}{m_p} = \frac{Qq}{4\pi\varepsilon_0 r^2}\frac{1}{m_p} = \frac{(+e)(+54e)}{4\pi\varepsilon_0 r^2}\frac{1}{m_p}$$	C1
	$$= \frac{54\left(1.60\times10^{-19}\right)^2}{4\pi\left(8.85\times10^{-12}\right)\left(2.0\times10^{-8}\right)^2}\frac{1}{1.67\times10^{-27}}$$ $$\left(= \frac{3.10(76)\text{ N}}{1.67\times10^{-27}\text{ kg}}\right)$$	M1
	$$= 1.9\times10^{16}\text{ ms}^{-2}$$	A1
3(b)(iv)	Gain in kinetic energy = loss in electric potential energy	B1
	$$\Delta E_K = qV_{\text{intial}} - qV_{\text{at infinity}}$$ $$= e\left(\frac{Q_{\text{nucleus}}}{4\pi\varepsilon_0 r} - 0\right)$$ $$= \frac{54\left(1.60\times10^{-19}\right)^2}{4\pi\left(8.85\times10^{-12}\right)\left(2.0\times10^{-8}\right)}$$	C1
	$$= 6.2\times10^{-19}\text{ J}$$	A1

Qns **Marks**

4(a)(i) Using Fleming's left hand rule, the proton will experience a magnetic force that is vertically upwards. Electric force on proton must act vertically downwards to balance the magnetic force. **B1**

Since Q is grounded and potential of P must be higher and so is positive polarity **B1**

Notes: type of force and direction was required

4(a)(ii)

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

$$v = \sqrt{\frac{2E_K}{m_p}} = \sqrt{\frac{2(64e)}{m_p}}$$ **C1** **C1**

$$\left(v = 1.1074 \times 10^5 \text{ ms}^{-1}\right)$$

$$F_e = F_B$$

$$qE = Bqv$$ **C1**

$$E = Bv = B\sqrt{\frac{2(64e)}{m_p}}$$

$$= \left(45 \times 10^{-3}\right)\sqrt{\frac{2\left(64\left(1.60 \times 10^{-19}\right)\right)}{1.67 \times 10^{-27}}}$$ **C1**

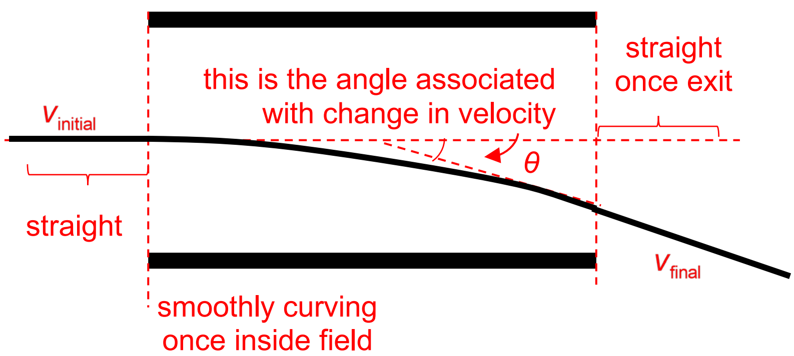
$$= 5000 \text{ N C}^{-1}$$ **A1**

Notes: common mistakes included not converting the energy from eV to Joule, and using the mass of electron instead of mass of proton.

4(a)(iii) $F_e > F_B$ **B1**

curve downwards [not parabola, so the acceleration is not constant]

Notes: attention to details in drawing are demanded. the particle experiences vertical force once inside the region so the path cannot continue straight for too long. the path must stretch to include the straight exit of the proton. see below for the dotted lines illustrating a sample construction:



Qns		Marks
4(b)	magnetic field surrounding X due to current in Y	
	$B=\dfrac{\mu_0 I_Y}{2\pi r}=\dfrac{(4\pi\times10^{-7})(8.4)}{2\pi(0.12)}$	
	$=1.4\times10^{-5}$ T	C1
	$F_X = BI_X L$	
	$\dfrac{F_X}{L}=BI_X$	
	$=(1.4\times10^{-5})(5.5)$	C1
	$=7.7\times10^{-5}$ N m^{-1}	A1
	To the right	A1
5(a)	energy transformed from chemical to electrical per unit charge that is driven round a complete circuit	B1
5(b)(i)	when switch is open, voltmeter reads e.m.f. of cell E = 12.0 V	A1
	effective resistance of S in parallel with T	
	$R_{\text{eff}}=\dfrac{(200)(300)}{200+300}$	C1
	$=120\ \Omega$	C1
	by potential divider rule	
	$\dfrac{V_{\text{terminal}}}{E}=\dfrac{R_{\text{eff}}}{R_{\text{eff}}+r}$	C1
	$r=R_{\text{eff}}\left(\dfrac{E}{V_{\text{terminal}}}-1\right)$	
	$=120\left(\dfrac{12}{10.8}-1\right)$	C1
	$=13.3\ \Omega$	A1
	OR	
	When switch is closed, voltmeter reads terminal p.d. which is also p.d. across S-in-parallel-with-T	
	$V_{\text{terminal}}=IR_{\text{eff}}$	
	$I=\dfrac{V_{\text{terminal}}}{R_{\text{eff}}}=\dfrac{10.8}{120}$	C1
	$=0.0900$ A	
	Consider p.d. across internal resistance	
	$V_r = Ir$	
	$r=\dfrac{V_r}{I}=\dfrac{12.0-10.8}{0.09}$	C1
	$=13.3\ \Omega$	A1

Qns		Marks
5(b)(ii)	$Pt = \frac{V_r^2}{r}(5.0 \times 60)$	C1
	$= \frac{1.2^2}{13.3}(5.0 \times 60)$	
	$= 32$ J	A1
	OR	
	$Pt = I^2 r(5 \times 60)$	C1
	$= 0.0900^2(13.3)(5.0 \times 60)$	
	$= 32$ J	A1
5(b)(iii)	resistance of NTC thermistor decreases as temperature increases effective resistance drops	B1
	overall current increases, resulting in larger p.d. across internal resistance	B1
	so terminal p.d. V drops	A1
	Notes: the discussion on p.d. across internal resistance is desired	
6(a)	Black holes that emit observable gravitational waves have masses about 30 times that our solar mass. The objects in our Solar System have masses too small to emit observable gravitational waves.	B1
	Notes: precision in terms was desired – discuss in terms of mass. so descriptions such as 'too small', 'not large enough', 'not heavy enough' was frowned upon	
6(b)(i)	maximum fractional change observed in Washington of 1.2×10^{-21} maximum change = $(1.2 \times 10^{-21})(4 \times 10^{3}) = 4.8 \times 10^{-18}$ m	A1
	Notes: question demanded change in (actual) *length*	
6(b)(ii)	increase the path that light takes by 280 times increases the path difference by 2 more orders	M1
	thereby increases phase difference so as to reduce the uncertainty in measurement of fractional change in length. **Notes:** question demanded the feature that allowed for reduced uncertainty or improved accuracy so likely hinting at a M1/A1 answer structure	A1
6(b)(iii)	the laser is split into 2 beams of constant phase difference of π	B1
	without gravitational waves, there is no path difference, so beams will meet in anti-phase and undergo destructive interference	B1

Qns		Marks
6(c)(i)	power $P = \frac{E}{t} = \frac{N}{t}(hf) = \frac{N}{t}\left(\frac{hc}{\lambda}\right)$	C1
	$\frac{N}{t} = \frac{\lambda P}{hc}$ $= \frac{(1064 \times 10^{-9})(100)}{(6.63 \times 10^{-34})(3 \times 10^{8})}$	C1
	$= 5.4 \times 10^{20}$	A1
6(c)(ii)	$\lvert \Delta p_{1\text{ photon}} \rvert = \lvert p_{\text{final}} - p_{\text{initial}} \rvert$ $= \lvert p - (-p) \rvert$ $= 2p$	
	$F_{\text{on } N \text{ photons}} = \frac{dp_{\text{total}}}{dt} = \frac{N}{t}(2p)$	C1
	$\lvert F_{avg} \rvert = \frac{N}{t}(2p) = \frac{N}{t}\left(2\frac{h}{\lambda}\right)$ $= (5.35 \times 10^{20})\left(2\frac{6.63 \times 10^{-34}}{1064 \times 10^{-9}}\right)$ $= 6.7 \times 10^{-7}$ N	C1
	By Newton's 3rd Law, force on photons is equal in magnitude and opposite in direction to force on mirror	A1
	Notes: there have been several momentum-change of photon questions of late – need to know if the photons were absorbed (final momentum zero) or reflected (final momentum same magnitude but opposite direction as initial)	
6(c)(iii)	Final momentum is zero. Change in momentum of absorbed photons is reduced by half. Hence smaller force. **Notes:** the reduction is <u>not</u> due to less photons	B1
6(d)(i)	difference in mass = $29 + 36 - 62 = 3$ solar masses	C1
	$E = \Delta mc^2$ $= 3(2.0 \times 10^{30})(3 \times 10^{8})^2$ $= 5.4 \times 10^{47}$ J	A1

Qns		Marks
6(d)(ii)	$I = \dfrac{P}{Area}$	C1
	$= \dfrac{E}{t}\left(\dfrac{1}{4\pi r^2}\right)$	C1
	$= \dfrac{5.4\times10^{47}}{20\times10^{-3}}\left(\dfrac{1}{4\pi\left(\left(1.3\times10^{9}\right)\left(9.5\times10^{15}\right)\right)^2}\right)$	C1
	$= 0.014\ \text{Wm}^{-2}$	A1
	Notes: a common mistake was not considering the surface area over which the power was spread across as that of a sphere. Another mistake was choosing the wrong time – it should be the time during which the energy from the black hole collision took place	
6(e)(i)	time of max fractional change at Washington: 0.4225 s time of max fractional change at Louisiana: 0.435 s difference in time: $0.435 - 0.4225 = 0.013$ s	A1
6(e)(ii)	speed $= \dfrac{\text{distance between Washington and Louisiana}}{\text{time}}$ $= \dfrac{3002\times10^{3}}{0.013}$ $= 2.3\times10^{8}\ \text{ms}^{-1}$	A1
6(e)(iii)	The gravitational wave is not travelling in free space. It is travelling through Earth, hence the speed may be altered. (analogous to light travelling in glass vs free space)	B1
6(f)1.	not effected by seismic movement of Earth so less noise	B1
6(f)2.	longer lengths of interferometer so more sensitive	B1
6(f)3.	ensures that gravitational waves will travel in free space, hence travelling at the speed of light	(B1)

Paper 3
Longer Structured Questions

Notes: candidates found questions more challenging when it was necessary to apply knowledge and understanding to unfamiliar or novel situations. Candidates appeared to have less experience of selecting relevant information and, under such circumstances, showed less clear understanding of the underlying concepts.

Qns		Marks
1(a)(i)	if no air resistance, $v^2 = u^2 + 2as$ $0 = 160^2 + 2(-9.81)s$ $s = 1300$ m	**C1** **M1**
	actual height is less than expected height under no air resistance, so air resistance is not negligible.	**A1**
	OR	
	Using conservation of energy to find maximum height	
	Notes: if alternatively, equation of motion is applied using the actual height to find the acceleration, need to mention that the acceleration found is an <u>average value else the equation is not valid in the first place.</u>	
1(a)(ii)	difference in gravitational potential energy due to the difference in max height = energy lost through work done against air resistance	**M1**
	$E_{loss} = mg\Delta h_{max}$ $= (0.92\times10^{-3})(9.81)(1300-1100)$ $= 1.81$ J	**A1**
1(b)	$F_{net} = W + F_{\text{air resistance}}$ $ma = mg + F_{\text{air resistance}}$ $a = g + \dfrac{F_{\text{air resistance}}}{m}$ $= 9.81 + \dfrac{3.4\times10^{-3}}{0.92\times10^{-3}}$ $a = 13.5$ m s^{-2}	**M1** **A1**
	Notes: Errors included (i) calculating deceleration due to air resistance alone, or (ii) not realizing that in upward motion, both weight and air resistance acts downwards so the magnitude of acceleration is greater than *g*.	

Qns		Marks
1(c)	$F_A \propto v^2 \;\rightarrow\; F_A = kv^2$	M1
	consider $(87,\ 1.0\times10^{-3})$ $k_1 = \dfrac{1.0\times10^{-3}}{87^2} = 1.3211\times10^{-7}$	
	consider $(120,\ 1.9\times10^{-3})$ $k_2 = \dfrac{1.9\times10^{-3}}{120^2} = 1.3194\times10^{-7}$	
	consider $(160,\ 3.4\times10^{-3})$ $k_3 = \dfrac{3.4\times10^{-3}}{160^2} = 1.3281\times10^{-7}$	M1
	largest percentage difference $\dfrac{k_3-k_2}{k_2}\times100\% = \dfrac{1.3281-1.3194}{1.3194}\times100\%$ $= 0.66\%$	
	the 3 *k*'s are approximately equal in value and exhibit a largest percentage difference of under 1%	A1
	Notes: need to consider points whose (*x)* coordinates are well-distributed along the graph (as per the *x* range provided in the question). In trying to confirm if a constant of proportionality exists, 2 s.f. is insufficient.	

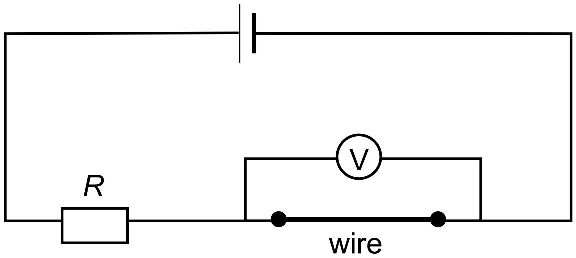
Qns		Marks
2(a)	Gravitational force provides centripetal force	B1
	let m_s = mass of satellite and r_s = satellite's radius of orbit from planet centre	
	$\frac{GMm_s}{r_s^2} = \frac{m_s v_s^2}{r_s}$ $\frac{GMm_s}{(R+h)^2} = \frac{m_s v_s^2}{R+h}$	M1
	$v_s = \sqrt{\frac{GM}{R+h}}$	A1
	Notes: When symbols are already defined in question, they are safe to use without further assignment. For similar questions, take note define any new symbols used.	
2(b)	gain in kinetic energy = loss in gravitational potential energy	B1
	$\frac{1}{2} m_{\text{rock}} V^2 - 0 = m_{\text{rock}} \phi_{\text{initial}} - m_{\text{rock}} \phi_{\text{final}}$	C1
	$V^2 = 0 - 2\phi_{\text{final}}$ $V^2 = 0 - 2\left(-\frac{GM}{R+h}\right)$	
	$V = \sqrt{2\frac{GM}{R+h}}$	A1
2(c)	V is larger than v_s at same height h	M1
	so stone could not enter into orbit	A1

Qns		Marks
3(a)(i)	$pV = nRT \rightarrow V \propto T$	
	$\dfrac{V_A}{T_A} = \dfrac{V_B}{T_B}$	
	$\dfrac{2.8\times10^{-3}}{315} = \dfrac{7.6\times10^{-3}}{T_B}$	M1
	$T_B = 860 \text{ K}$	A1
3(a)(ii)	$w_{by} = p\Delta V = p\left(V_{\text{final}} - V_{\text{initial}}\right)$	
	$= p\left(V_{\text{B}} - V_{\text{A}}\right)$	
	$= \left(3.5\times10^{5}\right)\left(7.6-2.8\right)\times10^{3}\times\left(10^{-2}\right)^{3}$	M1
	$= 1680$	
	$= 1700 \text{ J}$	A1
3(b)	From B to C: $\Delta U = 0$ (isothermal process for idea gas, $\Delta U \propto \Delta T$)	A1
	From C to A: $\Delta U = \dfrac{3}{2}(p_A V_A - p_C V_C) = -2520 \text{ J}$	A1
	From A to B: $\Delta U = \dfrac{3}{2}(p_B V_B - p_A V_A) = +2520 \text{ J}$	A1

Qns		Marks
4(a)(i)	Let upthrust be U at equilibrium position, $U = W_{\text{tube}} = Mg$ let submerged height at equilbrium be h $Mg = \rho(\text{volume submerged})g$ $M = \rho Ah$	B1
	resultant force $F = U' - W_{\text{tube}}$ $= [\rho(\text{volume submerged})' g] - Mg$ $= [\rho A(x+h)g] - Mg$ $= \rho Ahg - \rho Axg - Mg$ $= Mg - \rho Axg - Mg$ $= \rho Axg$	B1 A1
4(a)(ii)	$F = Ma$ $\rho Axg = Ma$ $a = \left(\frac{\rho Ag}{M}\right)x$	B1
	direction of *a* is upwards when cylinder is displaced *x* downwards, so *a* is opposite to *x* and proportional to negative *x* Hence $a = -\left(\frac{\rho Ag}{M}\right)x$ **Notes**: need to explicitly show/describe how the negative sign appeared	B1
4(b)	from (a)(ii): $a = -\left(\frac{\rho Ag}{M}\right)x$ simple harmonic: $a = -\omega^2 x$ $\omega = \sqrt{\frac{\rho Ag}{M}}$	C1
	$2\pi f = \sqrt{\frac{\rho Ag}{M}}$	C1
	$f = \frac{1}{2\pi}\sqrt{\frac{\rho Ag}{M}}$ $= \frac{1}{2\pi}\sqrt{\frac{(1.2\times10^3)\left(5.3\times(10^{-2})^2\right)(9.81)}{130\times10^{-3}}}$	M1
	$= 1.1\text{ Hz}$	A1

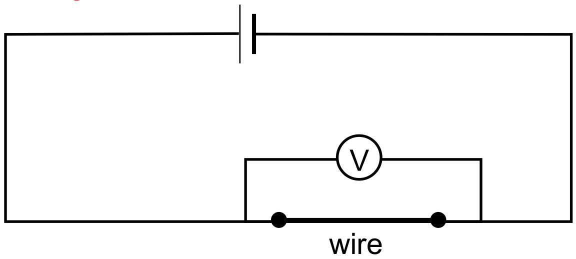
Qns		Marks
5(a)	$F = kx$	C1
	$27 = \left(1.8 \times 10^{4}\right)x$	
	$x = 1.5 \times 10^{-3}$ m	A1
5(b)	increase in $R = \dfrac{\rho x}{A}$	C1
	$= \dfrac{\left(3.2 \times 10^{-8}\right)\left(1.5 \times 10^{-3}\right)}{2.0 \times 10^{-7}}$	
	$= 2.4 \times 10^{-4}\ \Omega$	A1

5(c)

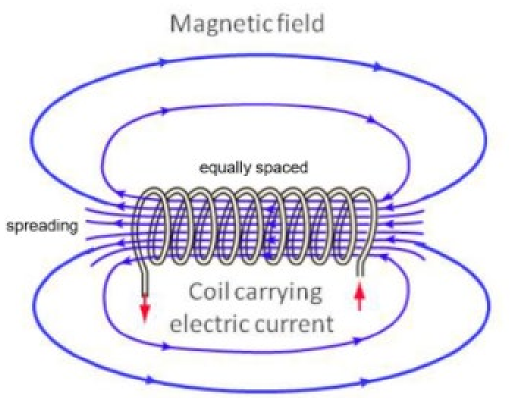


B1 – wire in series with resistor and cell
B1 – voltmeter across wire

Notes: need to be able to differentiate the connecting wires from the wire-under-test. Without fixed resistor, all we are reading is always terminal p.d. despite any change in resistance, as shown below:



Qns		Marks
6(a)(i)	$B = \mu_o n I$ $= \mu_o \left(\dfrac{900}{0.46}\right)(2.4)$ $= 5.9 \times 10^{-3}$ T	 M1 A1
	Notes: equation for solenoid can be found from formula list at the front of the booklet; *n* in the formula refers to the no. of coils per unit length	
6(a)(ii)	At centre of solenoid, magnetic flux lines are almost parallel and evenly spaced. At ends of solenoid, magnetic flux lines **spread out.** so magnetic flux density is lower at the ends as compared to centre.	B1 A1



6(b)(i)	induced e.m.f. in a conductor is proportional to the rate of change of the magnetic flux linkage.	M1 A1
6(b)(ii)	$E = -\dfrac{dNBA}{dt} = -NA\dfrac{dB}{dt} = -NA\dfrac{d}{dt}\mu_o nI = -NA\mu_o n\dfrac{dI}{dt}$ $= -(95)(\pi \times 0.008^2)\mu_o \dfrac{900}{0.46}\left(\dfrac{0-2.4}{1.5\times10^{-3}}\right)$ $= 0.075$ V	 M1 A1

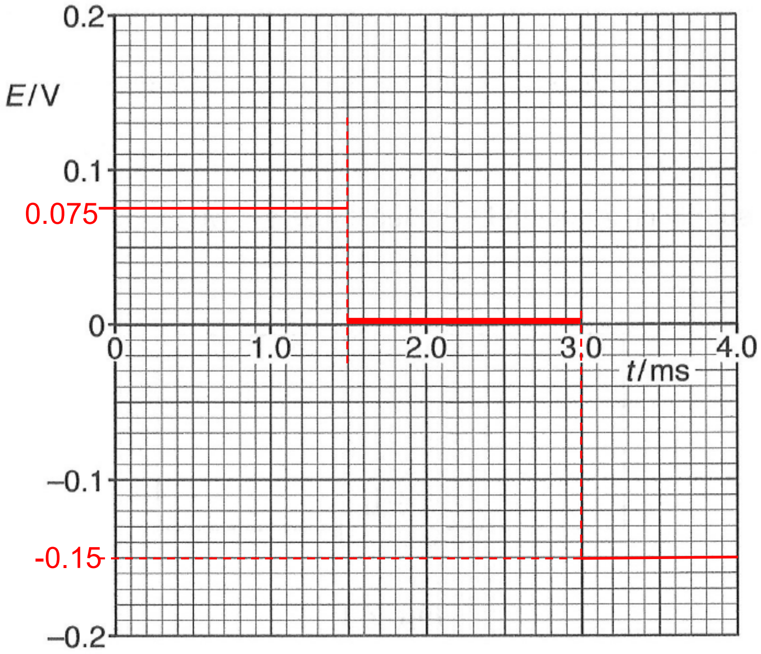
Notes:
1. Question asked for emf in *flat coil*, so *N* and *A* are of the flat coil, whereas *B* is the magnetic flux density *external to AND passing through* the flat coil.
2. *B* is produced by the solenoid, so in the *dB/dt*, the formula for *B* is the one by solenoid.

Qns	Marks
6(b)(iii)	

$$E_{3\ to\ 4} = -\frac{dNBA}{dt} = -NA\frac{dB}{dt} = -NA\frac{d}{dt}\mu_o nI = -NA\mu_o n\frac{dI}{dt}$$

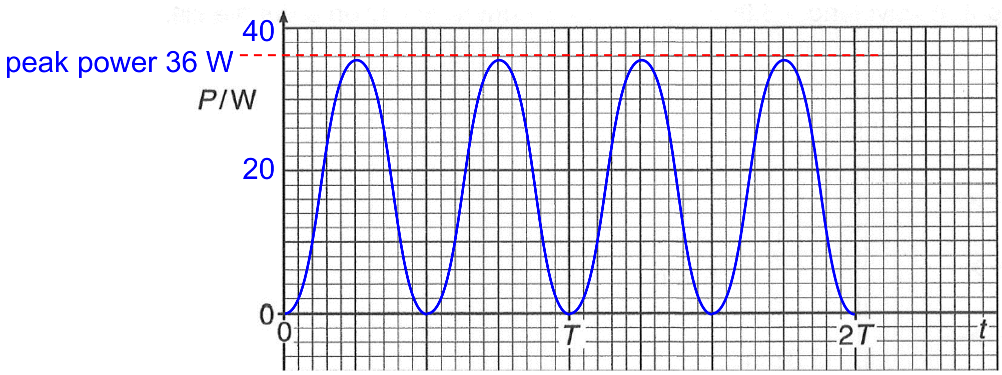
$$= -(95)(\pi \times 0.008^2)\mu_o \frac{900}{0.46}\left(\frac{3.2-0}{1\times 10^{-3}}\right)$$

$$= -0.15\ \text{V}$$



B1: non-zero for 0-1.5ms, non-zero for 3-4ms, zero outside these ranges
B1: different polarities for non-zero portions
B1: correct values (0.075 V and 0.15 V)

Qns		Marks
7(a)	value of a steady direct current that will dissipate thermal energy at the same average rate as the a.c. in a given resistor	B1 B1
7(b)(i)	$V_{rms} = \frac{V_O}{\sqrt{2}}$ $= \frac{24}{\sqrt{2}}$ $= 17\text{ V}$	M1 A1
7(b)(ii)	$\omega = 2\pi f = 440$ $440 = 2\pi f$ $f = 70\text{ Hz}$	A1
7(c)(i)	$P = \frac{V_{rms}^2}{R}$ $= \frac{17^2}{16}$ $= 18\text{ W}$	C1 A1
7(c)(ii)	$P = \frac{V_o^2}{R}$ $= \frac{24^2}{16}$ $= 36\text{ W}$	

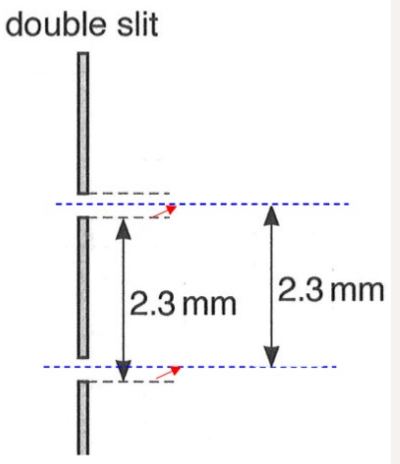
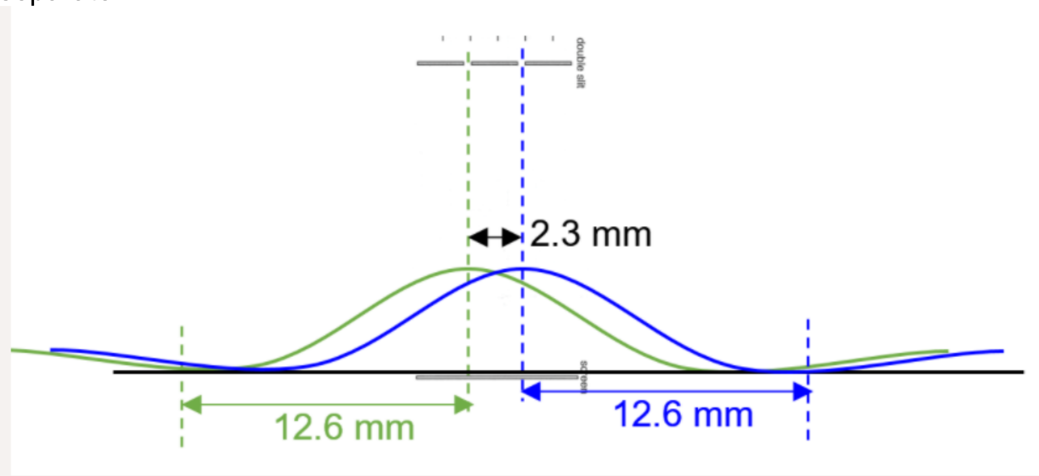


B1 – sine-squared shape with troughs at zero power
B1 – 2 sine-cycles so 4 peaks
B1 – correct peaks of 36 W and correct zero power at correct times

Notes:

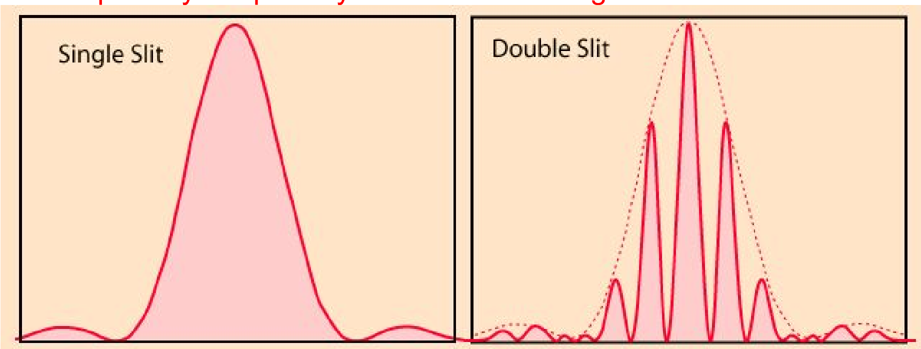
1. Label axis and peak value of power.
2. Shape of curve is at the x-axis is very important – it should be a smooth curve rather than sharp (ie. not the McDonald M type)
3. Tips to drawing curves – mark off the critical points which the graph must pass through first, then fill in the line in between the points

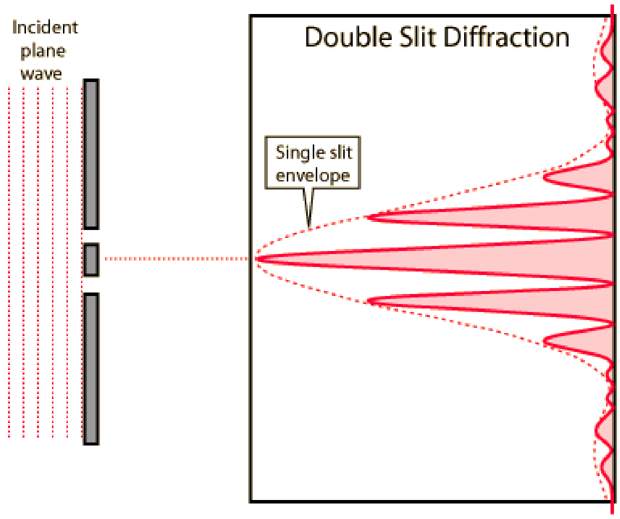
Qns		Marks
8(a)((i)	a <u>discrete packet of energy</u> of electromagnetic radiation,	B1
	Photon energy = Planck constant x frequency	B1
8(a)(ii)	Light waves have constant phase difference.	B1
8(b)(i)	$\sin\theta = \frac{\lambda}{b}$	C1
	$\frac{x}{3.2} = \frac{5.9\times10^{-7}}{0.15\times10^{-3}}$ where x is the distance from the first minima to the central maxima	C1
	$x = 0.01258$	C1
	$2x = 0.025$ m	A1
8(b)(ii)	When two objects are just resolved, they can be distinguished.	B1
	This happens when the first minimum of the diffraction pattern of one source coincides with the central maximum of the diffraction pattern of the other source	B1
	Notes: "diffraction pattern" is an important phase	

Qns		Marks
8(b)(iii)		
	From (b)(i), distance from central maximum to first minima = 12.6 mm	B1
	Distance between central maxima = 2.3 mm	M1
	Since 2.3 mm is less than 12.6 mm, diffraction pattern would not be seen as separate.	A1
		
8(b)(iv)	$x = \frac{\lambda D}{a}$	
	$= \frac{(5.9 \times 10^{-7})(3.2)}{2.3 \times 10^{-3}}$	C1
	$= 8.2 \times 10^{-4}$ m	A1

Qns		Marks
8(b)(v)	$\dfrac{0.025}{8.2\times10^{-4}} = 30.5$ ≈ 30	A1

Notes:
the diffraction pattern due to double slit (which of constant fringe separation) is "enveloped" by the primary effect due to a single slit.



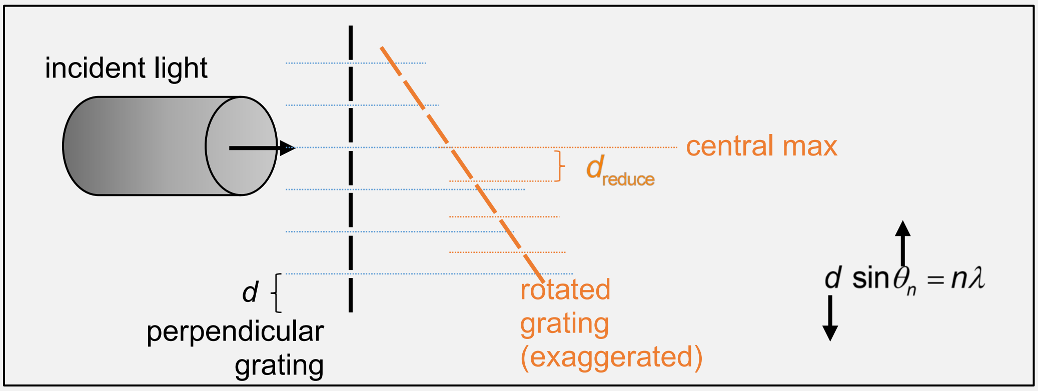


1. Value <u>must</u> be rounded <u>down</u> rather than up.
2. Value <u>must</u> be a whole number.

Qns		Marks
8(c)(i)	$d\ \sin\theta = n\lambda$ Maximum order number for Θ = 90° $d\ \sin\ (90°) = n_{\max}\lambda$	M1
	$n_{\max} = \dfrac{d}{\lambda}$ $= \dfrac{\left(\dfrac{10^{-3}}{750}\right)}{5.90\times10^{-7}}$ $n_{\max} = 2.25$ so maximum order is n = 2	M1
	$d\sin\theta = n\lambda$ $\dfrac{1\times10^{-3}}{750}\sin\theta = (1)5.9\times10^{-7} \Rightarrow \theta = 26.3°$ $\dfrac{1\times10^{-3}}{750}\sin\theta = (2)5.9\times10^{-7} \Rightarrow \theta = 63.3°$ $\theta = 0°,\ 26.3°,\ 63.3°$	A1
	Notes: Take note to include 0° (central bright fringe) as a maxima too.	

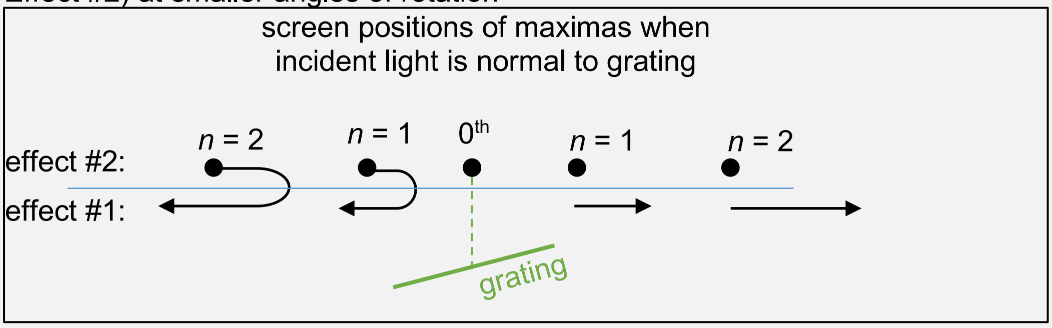
Qns		Marks
8(c)(ii)	Zero order maximum remains at the same position	B1
	all other orders of maxima shift opposite to the direction of rotation of grating	B1

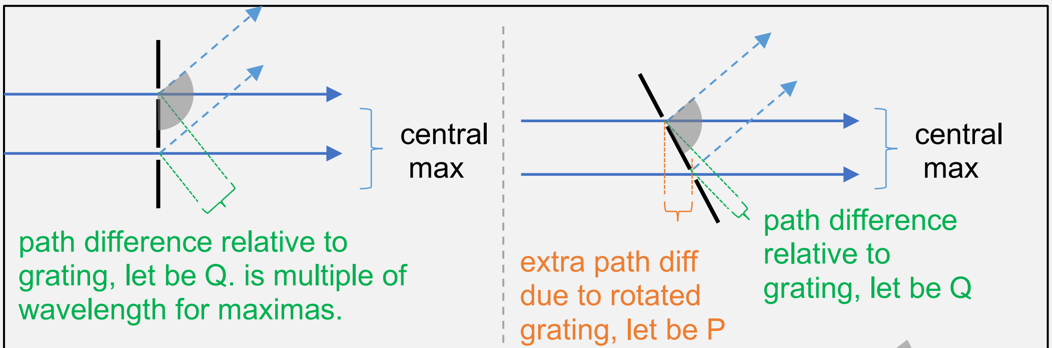
there are two competing effects:
Effect #1) in general the effective separation between slits reduces, so angle of diffraction increases



the results of this effect is *symmetric* about the central maxima

Effect #2) at smaller angles of rotation





consider n = 1 maxima: LHS: Q = 1 λ; RHS: P+Q = 1 λ. so angle relative to grating is smaller for RHS. explains why the angle "decreases" (effect 2)

i.e. where grating is further from screen ("left hand side")
- diffraction angle smaller than before for same order
- maxima's increasingly nearer away from central maximum compared to before
- higher order maxima may become visible
- maxima's intensity more than before for same order

where grating is nearer to screen ("right hand side")
- angle larger than before for same order
- maxima's increasingly further away to central maxima compared to before
- maxima's intensity less than before for same order
- higher order maxima may become evanescent (cannot be seen)

Qns		Marks
9(a)	**Radioactive decay** is a <u>spontaneous</u> and <u>random</u> process in which an unstable nucleus emits alpha particles, beta particles or gamma radiation to reach a more stable state.	B1 B1
	Nuclear fission is the splitting of a nucleus of high nucleon number into two smaller nuclei of approximately equal mass.	A1
	Nuclear fusion is the process where two nuclei of low nucleon number combine to form a more massive nucleus. **Notes**: Descriptions cannot be vague e.g. larger/smaller nuclei. Instead discuss nucleon number or mass.	A1
9(b)(i)	energy released from reaction $= \Delta mc^2$ $= (m_N + m_{He} - m_O - m_H)c^2$ $= (14.003074 + 4.002604 - 16.999130 - 1.007825)uc^2$ $= (14.003074 + 4.002604 - 16.999130 - 1.007825)(1.66 \times 10^{-27})(3 \times 10^{8})^2$ $= -1.91 \times 10^{-13}$ J Energy associated = 1.91×10^{13} J **Notes**: negative sign obtained for the energy released indicates that energy is required to initiate (set off) the reaction.	C1 C1 C1 A1
9(b)(ii)	from (b)(i), 1.91×10^{13} J of energy is <u>required to initiate</u> the reaction. kinetic energy of the α-particle is less than this, the reaction will not take place.	M1 A1
9(c)(i)	$E = \dfrac{hc}{\lambda}$ $1.06 \times 10^{-3} \times e = \dfrac{(h)3 \times 10^{8}}{\lambda}$ $\lambda = 1.06 \times 10^{-12}$ m **Notes**: 1m for conversion of MeV to J; 1m for E = hc/λ substitution; 1m for final answer	C1 C1 A1
9(c)(ii)	$p = \dfrac{h}{\lambda}$ $= \dfrac{h}{1.06 \times 10^{-12}}$ $= 6.20 \times 10^{-22}$ N s	 M1 A1

Qns		Marks
9(d)(i)	By conservation of linear momentum, total momentum before decay = total momentum after decay $0 = p_{\text{photon}} + p_{\text{recoiling nucleus}}$ $p_{\text{recoiling nucleus}} = -p_{\text{photon}}$	C1
	$E_K = \dfrac{p^2}{2m} = \dfrac{p^2_{\text{recoiling nucleus}}}{2m_{\text{recoiling nucleus}}} = \dfrac{p^2_{\text{photon}}}{2(60u)}$	C1
	$= \dfrac{(6.20\times10^{-22})^2}{2(60)(1.66\times10^{-27})}$	C1
	$= 1.93\times10^{-18}$ J	A1
9(d)(ii)	Kinetic energy of recoiling nucleus is about 12 eV. Photon has an energy of 10^5 times of the nucleus. hence negligible compared to photon energy	B1