2024 DHS H2 Physics Prelim Paper 3 Suggested Solutions

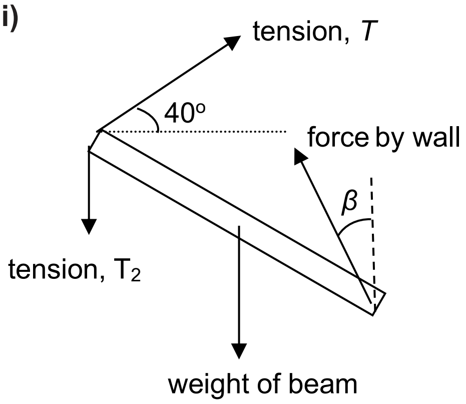
Section A

1 **(a)** Resultant force on it must be zero in any direction. **B1**

Resultant torque on it must be zero about any axis (of rotation). **B1**

MC:	Quite badly done. Missing key words in conditions stated. Marks penalized if there is no mention of about any axis (for torque) or in any direction (for force) in answers.

(b) **(i)**



Any 2 correct pairs of forces **B1**

Other 2 correct pairs of forces **B1**

With correct direction and label

MC:	The question specifically mention to draw in Fig 1.1, but some drew a separate diagram instead. BOD awarded if T_2 is replaced by weight of the 5.0 kg, Force by wall is not a normal force since it is not 90^0. Many students drew the force by the wall wrongly, they either assumed its horizontal, or along the beam.

(ii) Let x be the distance of c.g of beam from the hinge.

Taking moments about hinge,

sum of clockwise moments = sum of anticlockwise moments

$120\ (5 \sin 60^o) = 5g\ (5 \sin 70^o) + 20g\ (x \sin 70^o)$ **C1**

$x = 1.57 = 1.6$ m **A1**

MC:	Poorly done, because many could not obtain the correct clockwise or anticlockwise moment about the hinge. Some made mistakes when determining the necessary angle needed for calculations.

(iii) Vertical summation of forces:

$F_Y + 120\ (\sin 40^o) = 5g + 20g$

$F_Y = 168.1$ N

Horizontal summation of forces:

C1

$F_X = 120\ (\cos 40^\circ)$
$= 91.93\ \text{N}$

$F = \sqrt{F_X^{\,2} + F_Y^{\,2}} = \sqrt{91.93^2 + 168.1^2} = 192\ \text{N}$ **A1**

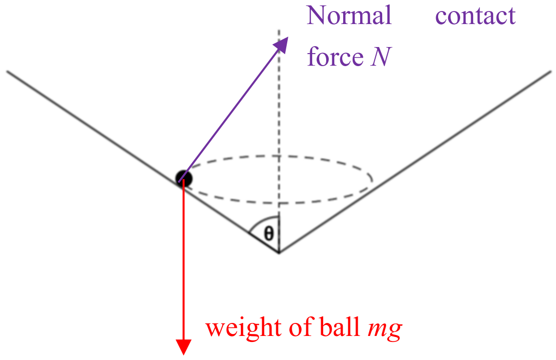
$\tan\beta = \dfrac{91.93}{168.1}$

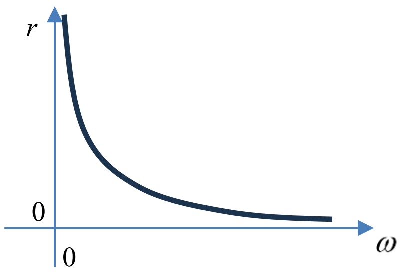
$\beta = 29^\circ$ **A1**

Force is at an angle of 41° with the beam **A1**

MC:	Many failed to resolve horizontally and vertically. A few did not calculate the numerical angle of the force by wall, while many did not express the angle correctly with the beam.

2(a)	In uniform circular motion, the **speed of the metal ball is constant**, but its **velocity** is **constantly changing direction**. Since **acceleration is the rate of change of velocity**, the metal ball experiences an acceleration.	**B1** **B1**
	OR In uniform circular motion, the **speed of the metal ball is constant**, but there is a **net non-zero force acting on the metal ball according to Newton's 1st law** because **it is moving in a circular path**. From **Newton's 2nd law for constant mass**, there must be an **acceleration in the same direction as the net force**.	 **B1** **B1**

CKW MC	• Most candidates demonstrated a lack of understanding regarding the significance of *uniform circular motion*. Paraphrasing the question, candidates should explain why a metal ball moving at a constant speed in circular motion is still considered to be accelerating. • Some candidates mentioned the presence of a centripetal force without explaining why the centripetal force exists • Some candidates explained why the metal ball experiences a centripetal acceleration and not an acceleration. • Some candidates quoted Newton's 2nd law in general or in mathematical form, without explaining why acceleration cannot be zero. • For the A-level syllabus, because of the general case of variable mass systems, a force can be defined as the rate of change in momentum, and it is the change in momentum that leads to the emergence of a force.	
2(b)(i)	 **Horizontal component of normal contact force** provides the **centripetal force**: $N\cos\theta = mr\omega^2$ --- (1) The **weight is balanced** by the **vertical component of the normal contact force**: $N\sin\theta = mg$ --- (2) (2) / (1) : $\tan\theta = \frac{g}{r\omega^2}$	**B1** **C1** **A0**

CKW MC	• Many candidates did not provide proper statements for the "show" question. • Quite a number of candidates recognized that tan θ is a ratio of *mg* and $mr\omega^2$ mathematically. However, they do not go on to explain how tan θ comes about from Newton's 2nd law, in the horizontal direction, and Newton's 1st law, in the vertical direction.	
2(b)(ii)	$\omega = 2\pi f = 2\pi(3) = 6\pi$ rad s^{-1} Since $v = r\omega$, $\tan\theta = \dfrac{g}{r\omega^2} = \dfrac{9.81}{0.10(6\pi)^2}$ $\theta = 15°$	**C1** **A1**
CKW MC	This part was generally well done, except for careless mistakes in calculations, e.g. forgetting to square, or conversion of units.	
2(c)		**A1**
CKW MC	• $\tan\theta = \dfrac{g}{r\omega^2}$ $\rightarrow$ For same θ and g, $r \propto \dfrac{1}{\omega^2}$. The graphs shows that as ω increases r decreases. • Some candidates did not realise there were 2 asymptotes. • Many candidates did not label the origin.	

3 **(a)** **(i)** When the gas molecules that are in continuous random motion collides with the inner wall of the bubble and rebounds, there is a change in velocity and hence a change in momentum. **B1**

By Newton's Second Law, the bubble walls will exert a force on the gas molecules. By Newton's Third Law, the gas molecules will exert an equal an opposite force on the inner walls of the bubble. **B1**

The force per unit area exerted by the gas molecules on the inner walls of the bubble gives rise to the pressure of the bubble. **B1**

MC:	Generally, the question was not very well done despite being rather lenient in the marking. Many responses were essentially a regurgitation of the answers that was used in Junior High/O-level without bringing in concepts learnt at the A-levels. Students need to be aware that the level and depth of their response must evolve in proportion to the level of the exam that they are sitting for. **<u>Some common misconceptions/issues include:</u>** • Gas molecules moving around and colliding **<u>with each other</u>** which causes a change in momentum (this is a violation of ideal gas assumption and also the wrong reason for the change in momentum of gas particles resulting in pressure) • Pressure was due to the collision of the gas molecules **<u>with water molecules</u>** (Pressure of gas is due to collisions of gas molecules with the inner walls of its container – appropriate terminologies should be used in explanations) • **<u>No explicit links made to Newton's 3rd law</u>** in their explanations. Many jumped straight to stating that since the gas molecules experienced a change in momentum, the gas molecules exert a force on the inner walls of the bubble. • There is a change in momentum of the inner walls of the bubble when the gas molecules collide (Note that while this is technically not a misconception, since $m_{\text{wall}} >> m_{\text{particle}}$, by using conservation of momentum, $v_{\text{wall}} \approx 0$ both before and after collision. - Therefore, it is more meaningful to centre the discussion based on the gas molecules.)

(ii) Since temperature constant:

$$p_1V_1 = p_2V_2$$

$$p_1\left(\frac{4}{3}\pi r^3\right) = (p_1 - h\rho g)(V_2)$$

$$(2.4\times10^5)\left[\frac{4}{3}\pi(0.015)^2\right] = \left[2.4\times10^5 - 14(1000)(9.81)\right]V_2$$ **C1**

$$V_2 = 3.3050\times10^{-5}\ \text{m}^3$$

$$= 3.3\times10^{-5}\ \text{m}^3$$ **A1**

MC:	Poorly done. Common (more eye-catching) issues include: • Erroneously assuming P_{atm} = 101325 Pa or 1.01×10^5 Pa. Values were given in the question to calculate the pressure of the atmosphere in this context. (Very common mistake) • Wrong formula used for the volume of sphere. A number of candidates used πr^2 instead. • Using diameter instead of radius to compute initial volume.

(b) (i) The First Law of Thermodynamics states that the increase in internal energy of a system **B1**
is the sum of the heat supplied to the system and the work done on the system. **B1**

MC:	Very commonly tested definition, which has **very specific keywords** that have been clearly outlined by the syllabus outcomes. Hence close to zero variance in answers will be accepted. (except minor things like swapping the order of Q and W in the definition) **Common mistakes:** • **Change or total** in internal energy • Heat supplied to **the gas** / work done on **the gas** (First law of thermodynamics applies to systems that are non-gaseous as well, for eg. Electrical circuits)

(ii) Since the bubble has expanded at a constant temperature, the work done on the gas is negative and the increase in internal energy of the gas is zero. **B1**
Hence, by the First Law of Thermodynamics, heat is added into the system. **B1**

MC:	Was decently done. Most students who applied the first law of thermodynamics were able to arrive at the correct conclusion. Those who tried using PV = nRT to were generally not successful in gaining credit.

(iii) The pressure of the bubble decreases. **A1**
A non-ideal gas has non-negligible intermolecular forces of attraction which reduces the average force exerted by the gas molecules on the walls of the container. **B1**

Do not Accept: Non-ideal gas will collide inelastically with the walls of the container and hence average force exerted by gas molecules to decrease.

MC:	Was decently done. Most students were able to state that the intermolecular forces of attraction would cause the pressure to decrease. Those who attained partial credit generally did not make the link between how intermolecular forces of attraction will cause pressure to decrease.

4 **(a)** **(i)** From Fig. 4.2, amplitude decreases with distance from the source. **B1**
Since intensity (or power) is proportional to (amplitude)^2, **B1**
wave is losing power as it moves away from the source.

MC:	When symbols were used in the explanation, there is a need to define the meaning of the symbols e.g. $I \propto A^2$ will not be accepted unless the meaning of I and A is explained.

(ii) intensity α (amplitude)^2

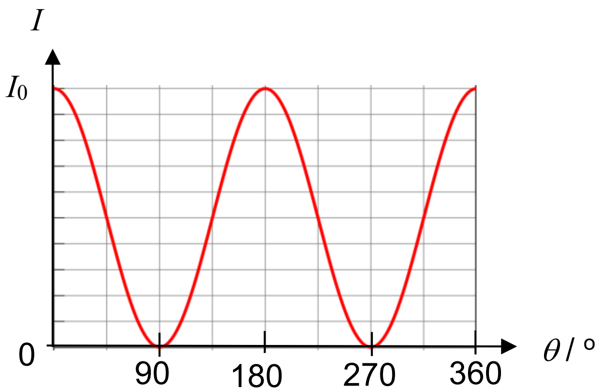
ratio = $\dfrac{(2.0)^2}{(1.1)^2}$ **M1**

= 3.3 **A1**

MC:	Students need to evaluate the ratio and not leave in fraction or ratio form.

(b) **(i)** $I = I_0 \cos^2\theta$ **A1**

(ii)



shape **A1**
correct values **A1**

MC:	While it is a sketch, students should also pay attention to the correct shape of the $\cos^2\theta$ graph, especially its turning points.

(iii) **1** After passing through A, intensity is still I_o, and after passing B,

$I_{AB} = I_o\cos^2 45^\circ$ **A1**

$= 0.5I_o$ **A1**

2 After passing through B, intensity becomes $0.5I_o$, and after passing through A, intensity $I_{BA} = 0.5I_o\cos^2 45^\circ$ **C1**

$= 0.25\ I_o$ **A1**

MC:	Never leave the final answer in fraction form.

5 **(a)** **(i)** This increases the magnetic flux linkage with secondary coil **B1**

(ii) This reduces heat/energy losses caused by eddy currents in the core **B1**

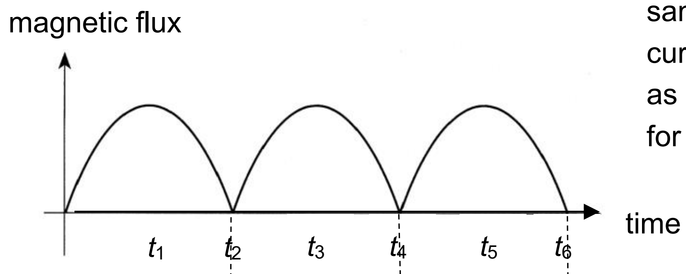
(b) The changing current in the <u>primary</u> coil gives rise to changing magnetic field and hence changing magnetic flux in the iron core. **B1**

The iron core <u>links</u> the magnetic flux in the <u>primary to the secondary</u> coil. **B1**

From Faraday's law, the changing flux in the <u>secondary</u> coil induces e.m.f. in <u>secondary</u> coil. **B1**

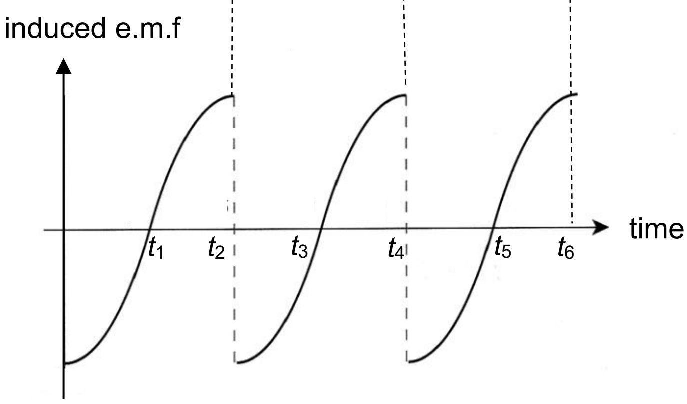
MC:	Generally poorly attempted. Some poor answers include: changing current causes changing magnetic flux and general statement of Faraday's law without applying it in context to the question does not gain credit.

(c) **(i)**



same change as current-time graph as *B* proportional to I for a solenoid.

(ii)



MC:	According to Faraday's law, e.m.f. induced in secondary coil = rate of change of magnetic flux linkage in secondary coil or $\varepsilon \propto \frac{d\Phi}{dt}$ Assuming number of turns is same for both primary and secondary coil, then flux linkage is the same in both coils. Graph of e.m.f. is the negative gradient of the magnetic flux-time graph.

(iii) **1** If the number of turns in the primary coil increases, the e.m.f. induced in the secondary coil decreases, assuming the number of turns in the secondary coil remains the same. **B1**
This is because the e.m.f. induced in the secondary coil is inversely proportional to the number of turns in the primary coil when the input p.d. also remains constant. **B1**

2 If the number of turns in the secondary coil increases, the e.m.f. induced across the secondary coil increases, assuming the number of turns in the primary coil remains constant. **B1**
This is because the e.m.f. induced in the secondary coil is directly proportional to the number of turns in the secondary coil when the input p.d. also remains constant. **B1**

MC:	Generally poorly done. Answers to (c)(iii) can easily be understood from the ideal transformer equation

6 **(a)** **(i)** Random means cannot predict when the decay will occur, or which nuclide will decay. **B1**
OR
Constant probability of decay per unit time **B1**

(ii) Spontaneous means occurs without any external stimuli such as changes in temperature or pressure. **B1**

MC:	For (a)(i) and (a)(ii), these are very commonly tested definitions, Hence, little variance in answers was accepted. Students are advised to be familiar with these definitions by hard. Generally not very well done. Most students had an idea of what the random and spontaneous mean, but many responses tended to have missing parts/keywords or students attempted to phrase it in their own way.

(b) **(i)** Gamma radiation has a greater penetrating power and will penetrate through a thin sheet of aluminium foil with little loss in intensity. **B1**

Any differences in the intensity of gamma radiation detected by the detector due to variations in the foil thickness would be too small to detect easily. **B1**

MC:	Many candidates were at least able to hint at the penetrating power being greater for gamma radiation. However, usage of keywords such as "penetrating power" was generally very poorly utilized. Most candidates ended up listing examples to illustrate this point. Most students also fell short in re-contextualisation of their answers to answer the question. Most just stated that the penetrating power is greater without making the link or explaining how it would affect the operation of the setup in the question. Hence, most candidates could only score partial credit at best. **Common misconceptions:** • **All** gamma radiation will pass through the foil regardless of thickness (false – there is attenuation albeit a very small/negligible amount, which does alter the count rate received by the detector) • The machine will recognize an increase in thickness if the count rate of beta particles is zero. (not necessarily true as the machine can operate by ensuring a fixed count rate, thickening of the foil can cause the count rate to decrease but not necessarily reach zero)

(ii)

$$\lambda = \frac{\ln 2}{t_{1/2}}$$

$$= \frac{\ln 2}{14 \times 24 \times 60 \times 60}$$ **C1**

$$= 5.7303 \times 10^{-7}$$

$$= 5.7 \times 10^{-7} \text{ Bq}$$ **A1**

(iii)

$$A = A_0 e^{-\lambda t}$$

$$\frac{A}{A_0} = e^{-\lambda t}$$

$$= e^{-\left(\frac{\ln 2}{14 \times 24}\right)8}$$ **C1**

$$= \left(\frac{1}{2}\right)^{\frac{8}{14 \times 24}}$$

$$= 0.98363$$

$$= 0.98 \text{ (to 2sf)}$$ **A1**

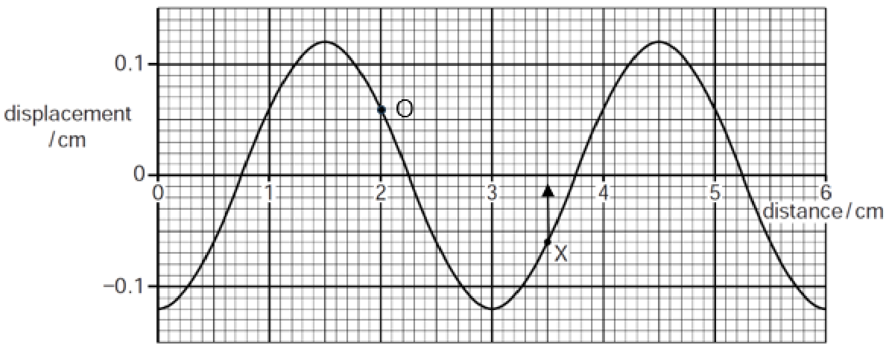
MC:	(ii) and (iii) were generally well answered. A vast majority who attempted were able to score full credit for these two parts.

(iv) When the detector detects a lower count rate, the set up interprets the decrease in count rate as a thickening of the foil. <u>To maintain a constant foil thickness at the original calibrated value</u>, the separation of the rollers decreases. **B1**

Hence, the foil thickness <u>decreases</u>. **B1**

MC:	Most candidates were able to identify that the foil thickness will decrease. However similar to (b)(i), many were not able to link their answers to the context of the question. Majority was also showed **very poor command and usage of key terms** (eg. Activity, count rate). Most did not showcase a good understanding of how the set up works but only seemed to have a vague idea of what the machine does. Incomplete answers included: • When the activity of the source decreases, the machine will thin the foil to increase the count rate. (missing: to ensure that the count rate detected by the detector remains the same at the calibrated value)

Section B

7(a)(i)	O is on the line in an adjacent segment of X, that is not a node.	**A1**
CKW MC	This part was well done	
7(a)(ii)	arrow drawn at X pointing vertically upwards 	**A1**
CKW MC	This part was generally well done, although there were answers in other directions.	
7(a)(iii)	distance = 2 x 0.06 cm = 0.120 cm	**A1**
CKW MC	This part was well done, though some candidates did not realise the distance travelled was for half a period.	

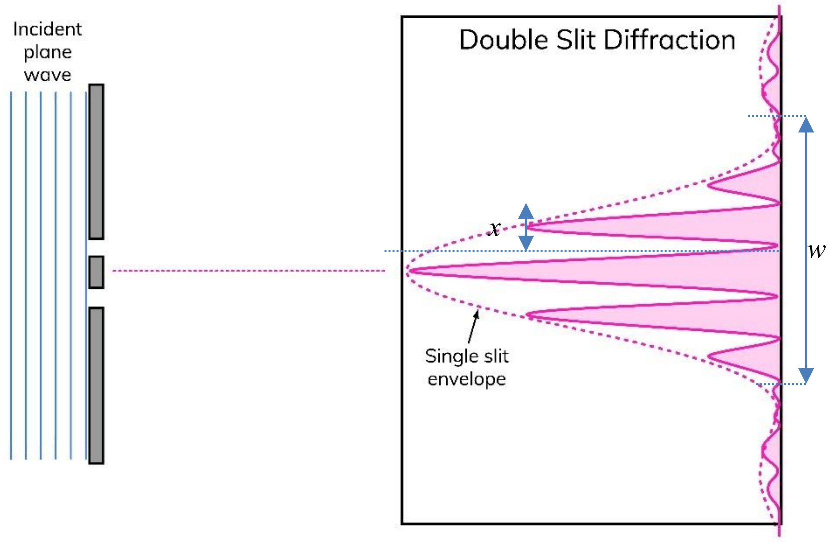
7(b)	$\frac{1}{2}\lambda = 65.0$ cm speed = 0.650 x 2 x 256 = 333 m s^{-1}	**M1** **A1**
CKW MC	Some candidates did not deduce the correct wavelength.	
7(c)(i)	$b \sin\theta = \lambda$ $\sin\theta = \dfrac{633 \times 10^{-9}}{0.0800 \times 10^{-3}}$ $\theta = 0.453°$ w = 2×5.12×tan θ = 2×5.12×tan (0.453°) = 0.0810 m	**C1** **A1**
CKW MC	This part was generally well done. Usually, the wrong answer was off by a factor of 2.	
7(c)(ii)1.	**Destructive interference** occurs when light from second slit meets **anti-phase** with light from first slit.	**B1**
CKW MC	This part was well done	
7(c)(ii)2.	$x = \dfrac{\lambda D}{a} = \dfrac{(633 \times 10^{-9})(5.12)}{0.240 \times 10^{-3}}$ = 0.0135 m	**C1** **A1**
CKW MC	This part was well done	
7(c)(ii)3	$w = 6x \approx 0.0810$ m (The 3rd maxima from the central maxima of the double-slit interference pattern coincides with the 1st order minima of the single slit spectrum due to the width of the slit.) These places are **minima of the single slit** envelope.	**B1** **B1**

CKW
MC

Realistic Double Slits

In real life, the double slits are never infinitely thin (they are not really point sources), they actually have a width.

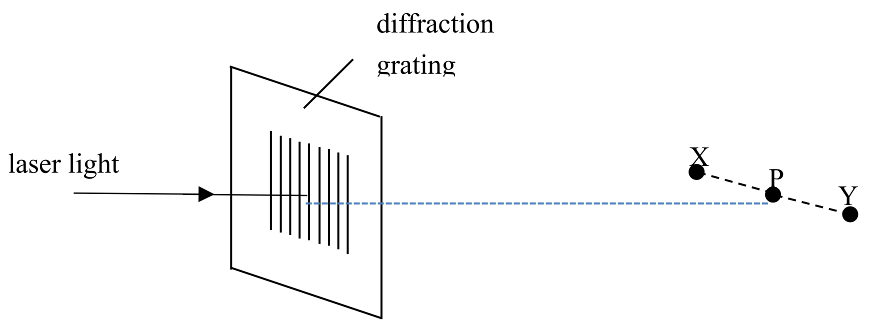
- This means that each of the two slits will generate a single-slit diffraction pattern.
- The result is that we have a **single-slit envelope** with the pattern of dark and bright fringes from the actual double slit interference.



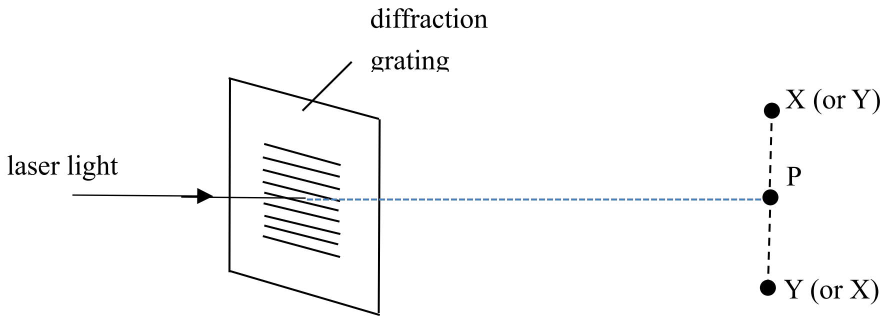
- To get information about the **distance** between the two slits, you have to look at maxima generated by the **double slit pattern**.

- To get information about the **width** of each slit, you have to look at the **position of the 1st order minima** of the single slit envelope.

7(d)(i)	tan $\theta = \frac{38}{165} = 0.230$ or $\sin\theta = \frac{38}{\sqrt{38^2 + 165^2}} = 0.224$ or $\theta = 12.97^\circ$ $d \sin\theta = \lambda$ $d \sin 13^\circ = 6.33 \times 10^{-7}$ $d = 2.82 \times 10^{-6}$ m number per metre = $\frac{1}{d}$ = **3.5×10^5 m^{-1}**	C1 C1 A1
CKW MC	• Most candidates omitted the unit. • Small angle approximation is not needed. $\theta = \frac{s}{r} = \frac{38}{165} = 0.230 = \tan\theta \neq \sin\theta$	
7(d)(ii)	**1** Lines are further apart in second order, than in first order. **2** Lines are brighter **and** sharper in first order, than in second order.	B1 B1
CKW MC	• Most candidates did not provide a complete comparison of the shape of the maxima i.e. both the intensity and width. • The wavelengths of 633 nm and 638 nm are too close for the colours to be different.	
7(e)(i)	P remains in the same position. X and Y rotate through 90°.	B1 B1



before rotation

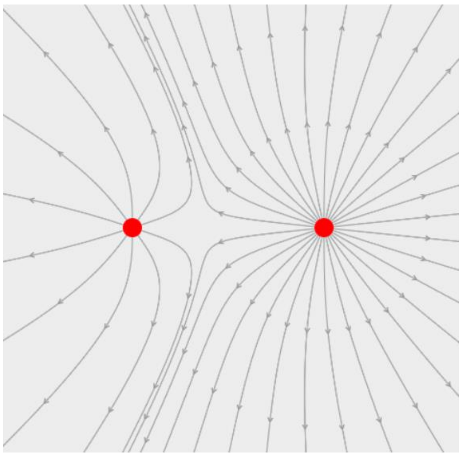
 after rotation		
CKW MC	• It is not possible to deduce if the rotation is clockwise or anticlockwise. • It is important to identify that the position of P is not affected, as it is possible that there is a translation in the diffraction pattern.	
7(e)(ii)	screen is not parallel to grating **OR** grating is not normal to incident light	**B1**
CKW MC	Many candidates did not realise the same grating was used, so the adjacent slit centre-to-centre separation remains unchanged.	

8(a)	Any one **[significant]** similarity and difference each: [Not just isolated point mass or isolated point charges!] [Not just small test mass or small test charge!] <u>Similarity</u>: • They are both regions of space in which an object can experience a non-contact force. • They are conservative. [Not in H2 syllabus; note magnetic fields are not conservative.] <u>Difference:</u> • Gravitational fields are created by mass while electric fields are created by charge. • Gravitational fields cause a mass placed in them to experience a force while electric fields cause a charge placed in them to experience a force. [**Learning Outcomes (a)** of the topics of “gravitational fields”, “electric fields” and “electromagnetism” require candidates to identify a gravitational field, an electric field and a magnetic field as *examples of a field of force*. For a magnetic field, it must be *produced by either by current-carrying conductors or by permanent magnets*.] • Electric fields can be shielded but gravitational fields cannot be shielded.	**B1** **B1**
CKW MC	• Some students confused *field* with *field strength*, *force* or the physical quantity that create it i.e. mass or charge. • Trivial similarity or difference without explaining the significance of the root words of *gravitational*, *electric & fields*, e.g. both are fields, or both can be represented by field lines, are not accepted.	
8(b)	Particle A: **Gravitational** field Particle B: **Electric** field Particle C: **Magnetic** field	**A1** **A1** **A1**
CKW MC	This part was well done though some candidates associate particle C with the presence of an electric field!	
8(c)(i)	The gravitational potential at a point is the **work done per unit mass** in bringing a **small test mass** from **infinity to that point**.	**B1**

CKW MC	Many candidates defined *gravitational potential energy* instead.	
8(c)(ii)	The magnitude of the **gravitational field strength** *g* is **numerically equal to the potential gradient** $\frac{dV}{dr}$. i.e. $\lvert g \rvert = \frac{dV}{dr}$ For the **same change in gravitational potential between adjacent equipotential lines** $(\Delta V = 2.0 \text{ MJ kg}^{-1})$, the **separation between <u>adjacent</u> equipotential lines** (Δr) **increases** as the distance from the surface (or centre) of the Mars increases.	**B1** **B1**
CKW MC	• Some candidates used mathematical expressions without defining them in their explanations. • Many candidates did not show an understanding of the difference between *change in gravitational potential* ΔV and *gravitational potential V* or distance from centre of Mars *r* and separation between the (adjacent) equipotential lines Δr. • The definition of gravitational field strength is *not* the rate of change of gravitational potential or $\frac{dV}{dt}$. As per **Learning Outcomes (c) and (j)** of the topic of “electric fields”, candidates need to relate field strength to the concept of potential gradient.	
8(c)(iii)	$\lvert \Delta U_G \rvert = \frac{1}{2}mv^2$ $m(\phi_x - \phi_y) = \frac{1}{2}mv^2$ $v = \sqrt{2(\phi_x - \phi_y)}$ $= \sqrt{2(-6.0 + 8.0) \times 10^6}$ $= 2000 \text{ m s}^{-1}$	**M1** **C1** **A1**
CKW MC	This part was generally well done	

8(d)(i)	For gravitational potential at a point, the **displacement of a small test mass from infinity to that point** is always in the **opposite direction to the external force** acting on the small test mass because gravitational forces between two masses are always attractive. For electric potential at a point, the **displacement of the small test charge from infinity to that point** can be in the **opposite or same direction to the external force** acting on the small positive test charge because electric forces between two charges can be attractive or repulsive.	**B1** **B1**
	OR [w.r.t. to DHS G.Field Tut] Due to the **attractive** nature of the gravitational force, **work done by an external force** to bring any mass **from infinity to that point** is always negative. However, **electric** force can be **attractive or repulsive**, thus **work done by an external force** to bring any charge **from infinity to that point can be positive or negative**.	**B1** **B1**
CKW MC	Some candidates referenced the formulae for gravitational and electric potential in their discussions but failed to address the **key** conceptual difference between the two types of potentials, despite their similar definitions i.e. in terms of work done by an external force.	
8(d)(ii)	The **electric force** between an alpha particle and a gold nucleus is many orders of magnitude **larger than the gravitational force** between the alpha particle and gold nucleus.	**B1**

CKW MC	• A correct identification of the forces involved, and their comparison is needed to successfully answer this part. • No matter how small the gravitational force between an alpha particle and a gold nucleus is, if it is the only force present, then it cannot be neglected. • The order of magnitude of a gravitational force between two point masses is not only dependent on the product of the masses but also on the gravitational constant and the separation of the masses. • At the same separation r, the electric force is given by $F_e = \frac{(79e)(2e)}{4\pi\varepsilon_0 r^2}$ while the gravitational force is given by $F_g = G\frac{(197u)(4u)}{r^2}$. Thus, $\frac{F_e}{F_g} = \frac{(79e)(2e)}{4\pi\varepsilon_0 G(197u)(4u)}$ $= \frac{(79)(2)(1.6 \text{ x } 10^{-19})^2}{4\pi(8.85 \text{ x } 10^{-12})(6.67 \text{ x } 10^{-11})(197)(4)(1.66 \text{ x } 10^{-27})^2}$ $\approx 3 \text{ x } 10^{35}$	
8(d)(iii)	Assumption: The gold nucleus acts as a **point** positive **charge**. $V = \frac{Q}{4\pi\varepsilon_0 r}$ $= \frac{79(1.6 \times 10^{-19})}{4\pi(8.85 \times 10^{-12})(2.6 \times 10^{-12})}$ $= 43714$ $= 44000$ V	**B1** **C1** **A1**
CKW MC	• The assumption that "the gold nucleus is isolated" is not valid since the electric potential required is specified to be due to the gold nucleus in the question. • The formula used is only applicable for a point charge, which the gold nucleus is not physically in reality. • Some students thought the charge of a proton is 1 C.	

8(d)(iv)		**B1:** Direction of arrows **B1:** Position of neutral point (closer to alpha particle) **B1:** Field line pattern: • Field lines do not intersect. • Density of field lines around alpha particle is less than gold nucleus. • Symmetrical about the horizontal, asymmetrical about the vertical. • The circle represents an equipotential volume. The field lines are normal to the surface. [The suggested answer shows the simulated field lines between a charge of +1 C and +5 C. The actual field lines between a charge of +2e & +79e is more asymmetric.]

CKW MC	• Some candidates sketched
	  ○ equipotential lines, or
	  ○ magnetic field lines
	• instead of electric field lines.
	
	• The imaginary line joining the points of zero resultant electric field strength were observed to vertically straight in many cases; this is only possible if the charges have the same magnitude and same sign.
	
	Some sites to simulate electric field lines between two point charges:
	  ○ E-Field Simulation - Ithaca College PER
	  ○ Electric field line simulator	