PHYSICS

Units 3 & 4 – Written examination

TSSM™
Creating VCE Success

2024 Trial Examination

SOLUTIONS

SECTION A: Multiple-choice questions (1 mark each)

Question	Answer
1	**A**
2	**D**
3	**D**
4	**C**
5	**A**
6	**B**
7	**A**
8	**A**
9	**C**
10	**A**

Question	Answer
11	**D**
12	**B**
13	**B**
14	**A**
15	**C**
16	**B**
17	**A**
18	**D**
19	**D**
20	**B**

Question 1

Answer: A

Explanation: Less than 9.8 ms^{-2}. There is air resistance opposing the force due to gravity, the net force will be less than the force due to gravity.

$$mg - Fair = ma$$
$$\Rightarrow a = g - \frac{Fair}{m}$$
$$\Rightarrow a < g$$

Question 2

Answer: D

Explanation: Zero acceleration when there is no change in speed. $a = \frac{\Delta v}{\Delta t} = 0$

Question 3

Answer: D

Explanation: E_g+E_k = a constant and when $t = 0, E_g = mgh_i$. Additional (kinetic) energy is added when the ball is thrown.
At $t = \frac{T}{2}$, height is a maximum, speed and thus E_k is a minimum, so E_g is a maximum.
At $t = T$, ball has returned to initial height so E_g is back to initial value, mgh_i

Question 4

Answer: C

Explanation:
Trial 1: Use $h = \frac{1}{2}g{t_1}^2$ and $R = Ut_1 \Rightarrow R = \sqrt{\frac{2hU^2}{g}}$
Trial 2: $4h = \frac{1}{2}g{t_2}^2$ and $R_2 = Ut_2 \Rightarrow R_2 = \sqrt{\frac{2(4h)U^2}{g}} = 2\sqrt{\frac{2hU^2}{g}} = 2R$

Question 5

Answer: A

Explanation: total mass = 20 kg; Net force = 20 – 15 = 5 N (LEFT)
Use *F* = *ma* ⇒ $a = \frac{F}{m} = \frac{5}{20} = \mathbf{0.25\ m\ s^{-2}}$

Question 6

Answer: B

Explanation: Use Work done = force x distance = 5x3 = 15**J**

Question 7

Answer: A

Explanation: Use $v = \frac{2\pi R}{T}$ and the cars complete the turn in the same time.
$R_A = 20$ m; $R_B = 25$ m
$\Rightarrow \frac{Speed_A}{Speed_B} = \frac{\frac{2\pi R_A}{T}}{\frac{2\pi R_B}{T}} = \frac{R(A)}{R(B)}$ = **0.8**

Question 8

Answer: A

Explanation: Use $a = \frac{4\pi^2 r}{T^2}$ *and* $R_A = 20\ m;\ R_B = 25\ m;$

$$\Rightarrow \frac{acceleration_A}{acceleration_B} = \frac{\frac{4\pi^2 r}{T^2}(A)}{\frac{4\pi^2 r}{T^2}(B)} = \frac{20}{25} = \mathbf{0.8}$$

Question 9

Answer: C

Explanation: The electric field between two parallel plates is constant. It is given by E = $\frac{V}{d}$

Question 10

Answer: A

Explanation:
$F = nBIl = (1)(0.4)(1.5)(0.1) = \mathbf{0.06\ N}$
Using the right hand slap rule, the force on side LM will be **upwards**.

Question 11

Answer: D

Explanation: The force (and therefore rotation speed) can be decreased by decreasing the number of turns as per $F = nBIl$. (**A** would increase the current. I, **B** would increase l, and **C** would increase B)

Question 12

Answer: B

Explanation: EMR and light travels at c in a vacuum. It is always the speed of 'light' in whatever medium is being traversed. The speed in a medium may be less than in a vacuum.

Question 13

Answer: B

Explanation: A string demonstrates transverse waves travelling in opposite directions which superpose to form a standing wave.

Question 14

Answer: A

Explanation: A standing wave is stable and all points move up-down. Point X is at its maximum upwards displacement in the position shown so it can only move downwards.

Question 15

Answer: C

Explanation:
$$\lambda = \frac{h}{p} = \frac{h}{mv} = \frac{6.63 \times 10^{-34}}{(9.1 \times 10^{-31})(7.6 \times 10^{6})} = 9.59 \times 10^{-11}\ m$$

Question 16

Answer: B

Explanation: Use diffraction varies with $\frac{\lambda}{w}$, the change to blue reduces the wavelength, which narrows the pattern. The increase in width (w) also narrows the pattern.

Question 17

Answer: A

Explanation: The Michelson-Morley experiment was attempting to detect the "Luminiferous Aether", a wind like substance they believed was spread out in all of outer space. They believed that if this was the case then light speed measured in the direction of the earth's orbit should be different than that measured at right angles to the earth's orbit. They did ***not*** find this difference.

Question 18

Answer: D

Explanation: The time interval measured from a frame where the two events occur at the same place (same point in space) is called proper time interval.

Question 19

Answer: D

Explanation: Independent variable is on the x axis (Magnetic Field Strength) while the dependent variable is on the y axis (Force).
The relationship between these variables is $F = nBI\boldsymbol{L}$ so the length of the wire, the current, and number of loops are controlled variables.

Question 20

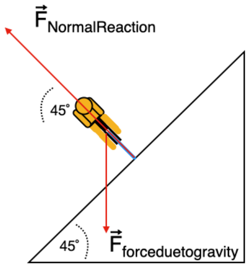
Answer: B

Explanation: The trend line is acceptable if it touches all uncertainty error bars

SECTION B: Short-answer questions

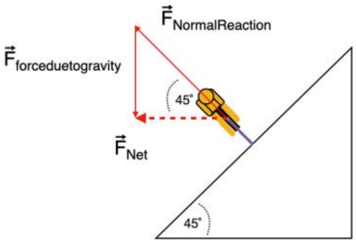
Question 1 (6 marks)

a. Force due to gravity (weight) – 1 mark
Normal reaction force - 1 mark



2 marks

b. Resolve forces



$F_{due\ to\ gravity} = mg$
Normal force: $F_{due\ to\ gravity} = N\cos\theta$
Centripetal force: Use $F_{NET} = \frac{mv^2}{r} = N\sin\theta$
$\Rightarrow \frac{v^2}{20g} = \tan 45^\circ \Rightarrow v = \sqrt{(20)(9.8)(\tan 45^\circ)} = \mathbf{14\ m\ s^{-1}}$ (50.4 km h^{-1})

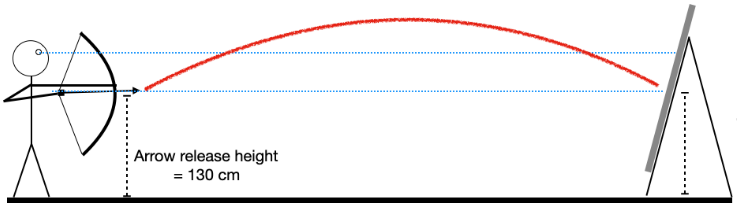
2 marks

c. Banking the track increases the centripetal force and reduces the friction which must be supplied by the tyres at higher speeds. The horizontal component of the normal force acts towards the centre of the circular path, contributing to the net force (and therefore the centripetal force). At low enough speeds, the horizontal component of the normal force is enough to keep the cycle moving in a circular path without the need for friction to keep the car moving in a circle. This reduces the chance that the cycle and rider will slide out on a slippery track surface.

2 marks

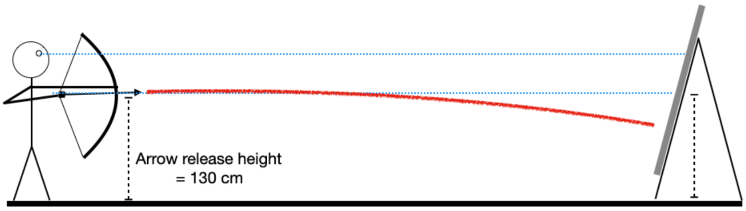
Question 2 (marks

a. Any path which has mid-point at maximum height, meets the target in the centre.



1 mark

b. There is an arrow drop when aimed and released horizontally.



**** NOT TO SCALE****

Step 1: Calculate time of flight to target

$v = 100 \text{ m s}^{-1}; d = 70 \text{ m}$

Use $d_h = vt$

$\Rightarrow ToF = \frac{70}{100} = 0.7 \text{ s}$

Step 2: Calculate arrow drop

$Arrow\ drop,\ \ d_v = \frac{1}{2}gt^2 = (0.5)(9.8)(0.7)^2 = 2.401 \sim 2.4 \text{ m}$, which is more than the original height of the arrow above the ground.

The arrow does not hit the target.

2 marks

c. Resolve launch vector

Horizontally:

$d = Vt\cos\theta$ where d = 70 m and V=100

$\Rightarrow 70 = 100t\cos\theta$

$\Rightarrow t = \frac{0.7}{\cos\theta}$

Vertically:

$h = Vt\sin\theta - \frac{1}{2}gt^2$ where h =0 and V = 100

$\Rightarrow 0 = 100t\sin\theta - \frac{1}{2}gt^2$

$\Rightarrow 0 = (0.7)(100)\frac{\sin\theta}{\cos\theta} - \frac{1}{2}g(\frac{0.7}{\cos\theta})^2$

$\Rightarrow [100\sin\theta - \frac{\frac{1}{2}g}{\cos\theta}](\frac{0.7}{\cos\theta})$=0

$\Rightarrow 2\sin\theta\cos\theta = \frac{g(0.7)}{100}$

$\Rightarrow \sin2\theta = \frac{(0.7)g}{100}$ = 0.0686 #

$\Rightarrow 2\theta = 3.934^{\circ}$

$\Rightarrow \theta = 1.96^{\circ} \sim \mathbf{2}^{\circ}$

2 marks

Alternatively

At top of flight path, $Vy = V\sin\theta - gt \Rightarrow t = \frac{V\sin\theta}{g} = 0$

$$Time\ of\ flight = \frac{2V\sin\theta}{g}$$

$$d = V\left(\frac{2V\sin\theta}{g}\right)\cos\theta = V^2\frac{2\sin\theta\cos\theta}{g} = \frac{V^2\sin2\theta}{g}$$

$\Rightarrow \sin2\theta = \frac{gd}{V^2} = \frac{(9.8)(70)}{(100)^2} = 0.0686$, then same as before [see # above]

Question 3 (9 marks)

a. $E_k = \frac{1}{2}mv^2$ where $d = 280$ km $= 2.8 \times 10^5$ m, $m = 40{,}000t = 4.0 \times 10^7$ kg and $t = 8$ hours$= 8 \times 60 \times 60$ s

$E_k = \frac{1}{2}(4.0 \times 10^7)(\frac{2.8\times10^5}{8\times60\times60})^2 = 1.89 \times 10^9$ J~ $\mathbf{1.9 \times 10^9}$ **J** ***(for the train)***

KE (each wagon)= $\frac{1.89\times10^9}{250} = 7.56 \times 10^6$ J ~$\mathbf{7.6 \times 10^6}$ **J** ***average wagon)***

2 marks

b. $\Delta E_k = \Delta E_g$

E_g=mgh=E_k [consequential answer]

$m = 5{,}000t = 5.0 \times 10^6$ kg

E_g=$(5.0 \times 10^6)(9.8)h = 1.89 \times 10^9$

$$h = \frac{1.89 \times 10^9}{(5.0 \times 10^6)(9.8)} = 38.58\ m\text{~}\mathbf{39\ m}$$

2 marks

c. The energy is gravitational potential energy where the force due to gravity on the train does work to increase the speed of the train when travelling downhill from the mine to the port. After unloading, and with fully charged batteries, the train returns uphill to the mine. Work is done by the train against the force due to gravity to increase the gravitational potential energy. Energy conservation states that any decrease in E_g provides an increase in E_k. However, instead of braking by converting $E_k$to heat energy, generators are used to convert the E_k to electricity and is stored in batteries to later power the electric locomotives.

Assumptions: (any two)

-sufficient storage is on-board

-conversion of E_k→ electricity is efficient

-there is sufficient fall in the line, without hills higher than where they started at the mine. ie all downhill..

3 marks

d. Use work done = force x distance

Work done to generate electricity by regenerative braking = $1.89 \times 10^9 J$

Distance = 800 m; Four axles per wagon; 250 wagons

$$W = 1.89 \times 10^9 J = F \times (800)$$

$\Rightarrow F = \frac{1.89\times10^9}{800} = 2.36 \times 10^6 N$ (force required to stop the train)

$\Rightarrow F = \frac{2.36\times10^6}{250} = 9.45 \times 10^3 N$ (force required to stop each wagon)

$\Rightarrow F = \frac{9.45\times10^3}{4} = 2.36 \times 10^3 N$ (force required to stop each axle) ~**2.4kN**

2 marks

Question 4

Two object m_A and m_B have the same E_k

Use $E_k = \frac{1}{2}mv^2$ and $p = mv$

$\Rightarrow 2mE_k = p^2$ ∴ The momentum is directly proportional to mass

Object A: $E_k(A) = \frac{1}{2}m_A v_A^2$ and momentum $p_A = m_A v_A \Rightarrow 2m_A E_k = p_A^2$

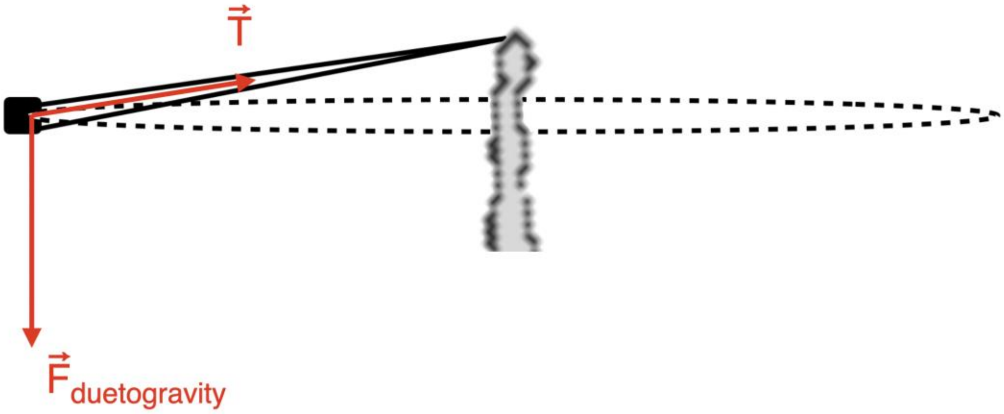
Object B: $E_k(B) = \frac{1}{2}m_B v_B^2$ and momentum $p_B = m_B v_B \Rightarrow 2m_B E_k = p_B^2$

⇒ **The larger mass will have the larger momentum**

3 marks

Question 5

a. two forces only: Tension and due to gravity



1 mark

b. Use $\vec{F} = \frac{mv^2}{r}$

m =200g = 0.200 kg; v = 35 m s^{-1} ; r = 165 cm = 1.65 m

$$F = \frac{0.2(35)^2}{1.65} = 1.485 \times 10^2 \sim 1.5 \times 10^2 = \mathbf{150\ N}$$

2 marks

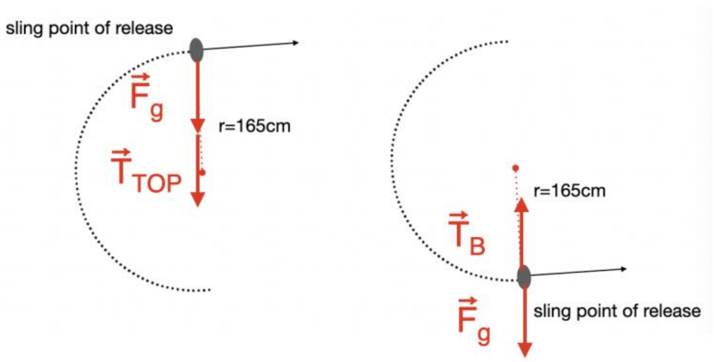
c. Comparing at point of release.

At the top the resultant force is $\vec{T}_{TOP} + \vec{F_g} = \frac{mv^2}{r}$

$\Rightarrow \vec{T}_{TOP} = \frac{mv^2}{r} - mg = 150 - 0.2 \times 9.8 = 148$ N

at the bottom resultant force = $\vec{T}_{BOTTOM} - \vec{F_g} = \frac{mv^2}{r}$

$$\Rightarrow \vec{T}_{BOTTOM} = \frac{mv^2}{r} + mg = 150 + 0.2 \times 9.8 = 152 \text{ N}$$



3 marks

d. Using projectile motion relationships.
Vertically: $height = vtSin\theta - \frac{1}{2}gt^2$
Horizontally: $range = vtCos\theta$
Time of flight: ToF= $\frac{2vSin\theta}{g}$
Range: $R = \frac{v^2Sin2\theta}{g}$
For an increase of range: (two only)
1. Increase release speed
2. Optimise launch angle to 45°
3. Increase the height of the release point from the ground.

3 marks

Question 6 (11 marks)

a. Spring constant = gradient force vs. Extension graph

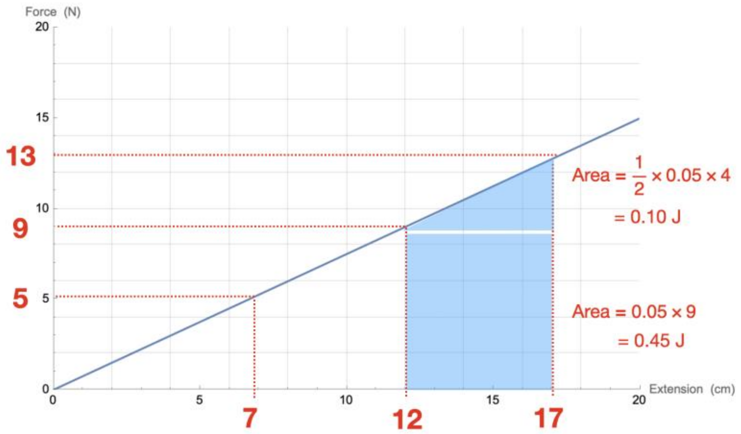
$$Spring\ constant\ k = \frac{\Delta F}{\Delta x} = \frac{15}{0.20} = \mathbf{75\ N\ m^{-1}}$$

Alternatively

For equilibrium*: mg=kx*

$$k = \frac{mg}{\Delta x} = \frac{(0.92)(9.8)}{0.12} = 75.13 \sim \mathbf{75\ N\ m^{-1}}$$

2 marks



b. Work done = Area under the *F* vs extension graph between $x = 12$ and $x = 17$
Area of a triangle [Work done = half x base x height]
Work done in triangle = $\frac{1}{2} \times 0.05 \times 4 = 0.10$ J
Work done in rectangle =$0.05 \times 9 = 0.45$ J
Total work done = **0.55 J**

Alternatively: area of trapezium[Work done = base x average height]
Work done1 = $\frac{1}{2} \times (9 + 13)0.05 = \mathbf{0.55\ J}$

2 marks

c. When released, Spring energy is converted to E_k and E_s
Total energy is a constant = E_s +E_k
E_g = 0 at lowest point $\Delta x = 17cm$ and maximum at $\Delta x = 7\ cm$
E_k = 0 at lowest point $\Delta x = 17cm$ and maximum at $\Delta x = 12\ cm$
E_s = 0 at highest point $\Delta x = 7\ cm$ and maximum at lowest point $\Delta x = 17cm$
It is arguable about zero energy for E_g and E_s at highest and lowest point.
So no marks for these ambiguous answers. (shaded cells)

Energy	Maximum energy	Minimum energy	ZERO energy
E_g	$\Delta x = 7$ cm	$\Delta x = 17$cm	Not applicable
E_k	$\Delta x = 12$ cm	$\Delta x = 7$ cm and 17 cm	$\Delta x = 7$ cm and 17cm
E_s	$\Delta x = 17$cm	$\Delta x = 7$ cm	Not applicable

Alternative terminology: T-top, B-bottom, C-centre

Energy	Maximum energy	Minimum energy	ZERO energy
E_g	T	B	Not applicable
E_k	C	T and B	T and B
E_s	B	T	Not applicable

One mark for each max/min pair plus zero E_k pair

4 marks

d. Maximum E_k at $\Delta x = 12\ cm$
$E_{TOTAL} = E_s + E_k + E_g$
ΔTotal energy =ΔE_s+ΔE_g+ΔE_k=0
$E_g = mgh$; $E_s = \frac{1}{2}k\Delta x^2$; $E_k = \frac{1}{2}mv^2$ where m=0.920 kg
$Work\ done = \Delta E_k + \ \Delta E_g = 0.55$ J [**CONSEQUENTIAL ANSWER** Q.6b]
$\Delta E_g = 0.92 \times 9.8 \times 0.05 = 0.45 \Rightarrow E_k = \frac{1}{2}mv^2 = 0.1$
$\Rightarrow v = \sqrt{\frac{2(0.1)}{0.920}} = 0.466 \sim \mathbf{0.45\ m\ s^{-1}\ (45\ \ cm\ s^{-1})}$

2 marks

e. Energy is converted to other forms of energy. Mostly heat energy to overcome opposing forces in the spring Also some energy transferred to air particles

1 marks

Question 7 (6 marks)

One mark for each correct row		**Gravitational field**	**Electric field around a point charge**	**Magnetic field of a solenoid**
a.	Can be attractive	✓	✓	✓
b.	Can be repulsive		✓	✓
c.	Can exist as a dipole			✓
d.	Can exist as a monopole	✓	✓	
e.	Is a static field	✓	✓	✓
f.	Has a uniform field			✓

Question 8 (8 marks)

a. Each planet has the same gravitational field, g. at the surface.

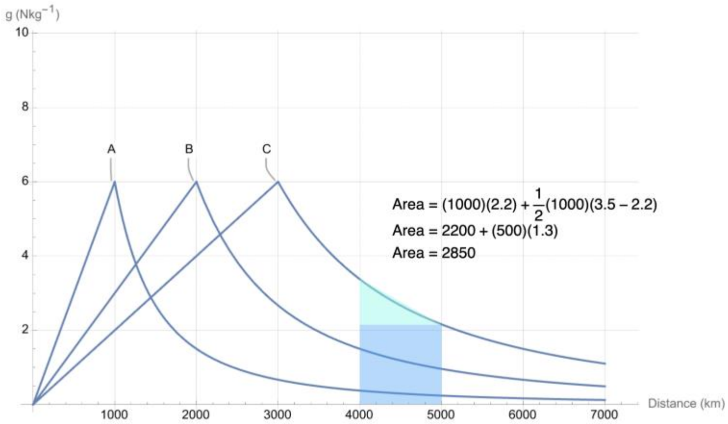
Planet	**Radius (km)**	**g field (N/kg)**
A	1000	6
B	2000	6
C	3000	6

Use $g = \frac{GM}{r^2} \Rightarrow M = \frac{gr^2}{G}$

$\Rightarrow \boldsymbol{Planet\ C\ has\ the\ greatest\ mass}$

2 marks

b. ΔE_g = mass x area under field-distance graph.



E_g = $2850 \times 10^3 \times 400 = \boldsymbol{-1.14 \times 10^9 J}$ (there is a loss of E_g)

E_g is converted to E_k when moving to a lower orbit.

2 marks

c. Find mass of planet A

$radius = 1000$ km

$g = 6.0$ N

$G = 6.67 \times 10^{-11}$

Use $g = \frac{GM}{r^2} \Rightarrow M = \frac{gr^2}{G} \Rightarrow M = \frac{(6.0)(1000000)^2}{6.67\times10^{-11}} = 8.996 \times 10^{22} kg \sim \mathbf{9.0 \times 10^{22}\ kg}$

2 marks

d. Period T for planet A

$m = 400\ kg$

$Altitude = 1000$ km $\Rightarrow r = 2000$ km $= 2.0 \times 10^6$ m; $g = 1.5$ N kg^{-1}

Use $g = \frac{4\pi^2 R}{T^2} \Rightarrow T = \sqrt{\frac{4\pi^2 R}{g}} = \sqrt{\frac{4\pi^2(2.0\times10^6)}{1.5}} = \boldsymbol{7255\ seconds \sim 7.3 \times 10^3}$

2 marks

Question 9 (5 marks)

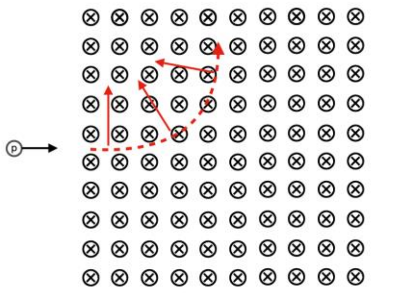
a. $r = \frac{mv}{qB}$

$$0.5 = \frac{(1.67 \times 10^{-27})(v)}{(1.6 \times 10^{-19})(0.06)}$$

$v = 2.87 \times 10^6$ m s^{-1}

1 mark

b. Arrow curving upwards. Force at three positions at right angles to direction of travel.



2 marks

c. Use $F = qvB = (1.6 \times 10^{-19})(2.87 \times 10^{6})(0.06) = 2.76 \times 10^{-14} \sim \mathbf{2.8 \times 10^{-14}}$**N**

2 marks

Question 10 (4 marks)

a. $r = 15\ \mu\text{m} = 15 \times 10^{-6} = 1.5 \times 10^{-5}$ m

Use $E = \frac{kq_1}{r^2}$

Charge(left) gives a field of $\frac{9\times10^{9}(+3Q)}{(1.5\times10^{-5})^2}$ $=1.2Q \times 10^{20}$ N C^{-1} to the right

Charge(below) gives a field of $\frac{9\times10^{9}(-2Q)}{(1.5\times10^{-5})^2}$= -8.0$Q \times 10^{19}$ N C^{-1} down

Net E-field =$\sqrt{(\mathbf{1.2Q \times 10^{20}})^2 + (\mathbf{8.0Q \times 10^{19}})^2} = \mathbf{1.442Q \times 10^{20}}$ **N/C**

~1.4 $\boldsymbol{Q} \times \mathbf{10^{20}}$ **N C^{-1}**

2 marks

b. Use $F = qE$

$F = 2Q^2E$ = **2.88**$\boldsymbol{Q^2} \times \mathbf{10^{20}}$ **N [CONSEQUENTIAL ANSWER Q10a]**

2 marks

Question 11 (6 marks)

a. In the speed selector, the charged particle travels undeviated.

$\therefore F_E = F_B \Rightarrow qE = qvB \Rightarrow v = \frac{E}{B} = \frac{2300}{0.045} = 5.111 \times 10^4$ m s^{-1} as required.

2 marks

b. At different speeds the particle travels along a variety of paths, only one speed has magnetic force and electric force adding to zero and allows the particle to travel straight. Other particles deviate left or right and miss the exit window which enters the deflector chamber where particles with different charge -mass ratios travel on a circle path with different radii.

2 marks

c. Use $r = \frac{mv}{qB} = \frac{(1.82\times10^{-26})(5.111\times10^{4})}{(1.6\times10^{-19})(0.045)} = 0.129\ metres \sim \mathbf{0.13}\ \boldsymbol{m}$

2 marks

Question 12 (7 marks)

a. Yes, the motor/coil will rotate anti-clockwise.

Using RH rule: Side YZ will move up/Side WX will move down

3 marks

b. Torque can be increased by: (any two)
-increasing the number of loops in the coil(number of coils)
-increasing the strength of the magnet/increase B field
-Increasing the Voltage/current/reduce resistance (thicker wire is heavier though)
-increasing the size(area) of the coil
Off-topic but correct
-improving bearings the coil rotates on
-make the coil lighter/reduce the mass of the coil

2 marks

c. Split ring commutator takes DC input, Slip rings require AC input for continued rotation. As the energy supply is DC battery, the motor will turn 90˚ then stop. Slip rings require a reversal of voltage/current every half turn. Split ring will provide continuous movement with a DC supply.

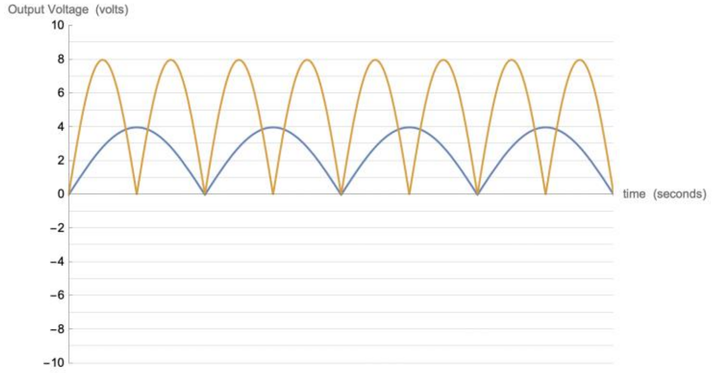
2 marks

Question 13 (4 marks)

a. Use $V_{PEAK} = \sqrt{2} \times V_{RMS} \Rightarrow V_{RMS} = \frac{\sqrt{2}}{2} V_{PEAK} = \frac{1.4 \times 4}{2} = \mathbf{2.8\ V}$

2 marks

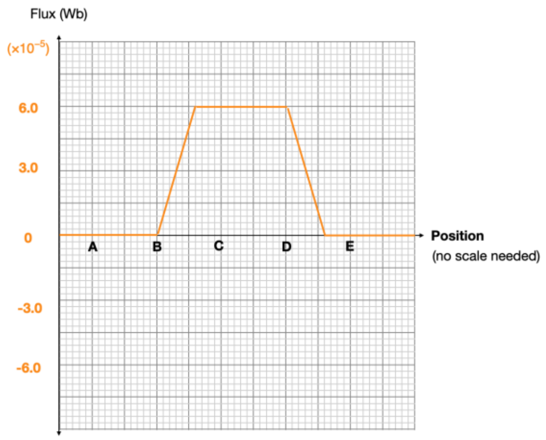
b. one mark voltage doubled (=8V)
one mark frequency halved



2 marks

Question 14 (8 marks)

a. $\phi_B = \vec{B}A = (0.0015)(0.20)^2 = 1.5 \times 10^{-3} \times 4.0 \times 10^{-2} = \mathbf{6.0 \times 10^{-5} Wb}$
One mark for calculation of flux

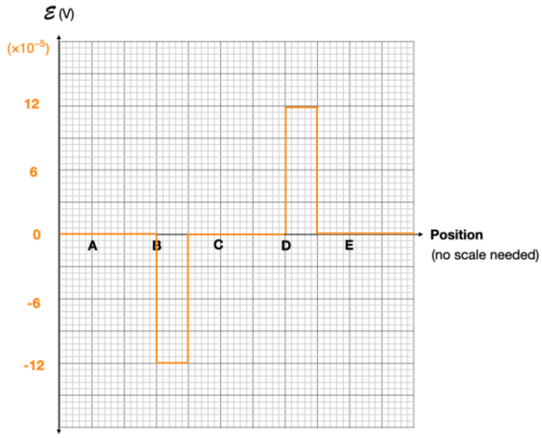


Two marks for graph:
-scale on vertical axis
Zero at A
Transition after B
6.0×10^{-5} Wb at C (maximum flux)
Transition after D
Zero at E

3 marks

b. EMF = $\frac{\phi_B}{\Delta t} = \frac{6.0\times10^{-5}}{0.5} = \mathbf{12 \times 10^{-5} \mathit{Volts}}$

One mark for calculation of EMF



Two marks for graph:
-scale on vertical axis
Zero at A
Transition after B
Zero at C (gradient flux)
Transition after D
Zero at E

3 marks

c. **Anti clockwise**

EMF opposes the change of flux (Lenz's law)
The flux is increasing into the page
so the induced flux is out of the page
RH rule indicates the current will be anti-clockwise (up at the leading edge)

2 marks

Question 15 (5 marks)

a. Use $\Delta x = \lambda L/d \Rightarrow L = \frac{d\Delta x}{\lambda} = \frac{(2.5\times10^{-4})(5.0\times10^{-3})}{(550\times10^{-9})} = 2.2727\ m \sim$ **2.27m**

2 marks

b. **Alice is correct.** Use the red laser.

Comparing wavelengths. Red is longer wavelength, blue is shorter wavelength.
Using $\Delta x = \lambda L/d$ where the band spacing (Δx) is directly related to the wavelength of incident light (λ). Choosing a larger value of λ will cause a larger value for Δx.
Alice is correct. Choose the red laser.

3 marks

Question 16 (7 marks)

a. Momentum $p = \frac{h}{\lambda}$ for both light and matter with wavelength 5 nm

$p = \frac{6.63\times10^{-34}}{5.0\times10^{-9}} = 1.326 \times 10^{-25} \sim \mathbf{1.3 \times 10^{-25}\ kg.m.s^{-1}}$

Since they both have wavelength of 5 nm, both have the same momentum.

2 marks

b. $Energy_{PHOTON} = pc = 1.326 \times 10^{-25} \times 3.0 \times 10^{8} = \mathbf{4.0 \times 10^{-17}\ J}$ (1)

$$Energy_{ELECTRON} = \frac{p^2}{2m} = \frac{(1.326 \times 10^{-25})^2}{2 \times 9.1 \times 10^{-31}} = 9.66 \times 10^{-21} = \mathbf{9.7 \times 10^{-21}\ J}$$

2 marks

c. $Velocity_{PHOTON} = \boldsymbol{c}\ or\ \mathbf{3.0 \times 10^{8}\ m\ s^{-1}}$;

Since the X-ray photon is an electromagnetic radiation, it travels at the speed of light,

$$Velocity_{ELECTRON} = \frac{p}{m} = \frac{1.326 \times 10^{-25}}{9.1 \times 10^{-31}} = 1.457 \times 10^{5} \sim \mathbf{1.5 \times 10^{5}\ m\ s^{-1}}$$

2 marks

d. Since the diffraction pattern depends on $\frac{\lambda}{w}$, and the wavelengths of the X-ray and electrons are same, in this case, they both would produce similar diffraction patterns.

1 mark

Question 17 (7 marks)

a. One mark each row

	Prediction	Particle model	Wave model
i.	The number of photoelectrons produced is proportional to the intensity of the incident beam.	**Y**	Y
ii.	Light of sufficient intensity should produce the photoelectric effect.	**N**	Y
iii.	Light of high intensity will produce photoelectrons with a greater maximum kinetic energy then light of low intensity.	**N**	Y
iv.	Light of low intensity will cause the emission of photoelectrons later than light of high intensity.	N	**Y**

4 marks

b. Einstein's interpretation supported a particle model. (1) The Work function was different for different metals. Light of high intensity took the same amount of time (1) for an electron to be emitted, once a threshold energy had been exceeded. Increased frequency of the incident light, increased the energy of the electron released from the metal. (1)

3 marks

TOTAL SECTION B
110 MARKS