Neap

Trial Examination 2021

VCE Physics Unit 3

Written Examination

Suggested Solutions

SECTION A – MULTIPLE-CHOICE QUESTIONS

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

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Question 1 C

C is correct. The diagram could represent an electric field around a positive charge or a gravitational field around a central mass. **A** is incorrect. The diagram could also represent a gravitational field. **B** is incorrect. The diagram could also represent an electric field. **D** is incorrect. The diagram could represent both a gravitational field and an electric field.

Question 2 C

C is correct. The plate on the left is negative and the plate on the right is positive. A positive charge will be attracted to the negative plate. The field is initially perpendicular to the velocity of the charge and it bends the path of the particle. That is, it changes both direction and magnitude of v. **A** is incorrect. The particle would deviate when it enters the electric field. **B** is incorrect. The particle would not follow a linear path. **D** is incorrect. The particle would bend towards the plate as the net force is to the left.

Question 3 A

A is correct. The right-hand slap rule, Fleming's left-hand rule or an equivalent rule can be used. With the thumb pointing left (the direction of the current's flow is opposite to the direction of negative charge velocity), the fingers are out of the page and the palm is up. **B** is incorrect. This would be the direction of the force acting on a positive charge. **C** and **D** are incorrect. The magnetic force is perpendicular to the direction of travel.

Question 4 B

B is correct. Direct current (DC) is an electric current in which the flow of charge is always in the same direction (all positive or all negative) and may be variable. In graph II, the direction of the flow of charge is in both the positive and negative direction. **A** is incorrect. Graph I shows steady DC EMF. **C** is incorrect. Graphs III and IV both show current in one direction, even though it is not steady EMF. **D** is incorrect. Graph II is not DC, but graphs III and IV are.

Question 5 B

$$v = \sqrt{\frac{GM}{r}}$$

Increasing the radius by a factor of 4 would decrease the velocity by a factor of 2.

Question 6 C

$$\tan\theta = \frac{v^2}{rg}$$

$$v = \frac{36.0}{3.6}$$

$$= 10 \text{ m s}^{-1}$$

$$\tan\theta = \frac{10^2}{45 \times 9.8}$$

$$\theta = 13°$$

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Question 7 B

$$F_N = ma$$
$$F_T = 5.0 \times 1.0$$
$$= 5.0 \text{ N}$$

Question 8 B

$$E_{T_X} = E_{T_Y}$$

$$m \times g \times h = \frac{1}{2}mv^2 \quad \text{(cancel out } m\text{)}$$

$$9.8 \times 20.0 = \frac{1}{2}v^2$$

$$v = 19.8 \text{ m s}^{-1}$$

$$v = u + at$$

$$19.8 = 0.0 + a10.0$$

$$a = 1.8 \text{ m s}^{-1}$$

$$F_{net} = ma$$
$$= 80.0 \times 2.0$$
$$= 160 \text{ N} \quad \text{(to 3 significant figures)}$$

Question 9 B

$$l_x = \frac{l_0}{\gamma}$$
$$= \frac{50.0}{2.00}$$
$$= 25.0 \text{ m}$$

B is correct. Length contraction only occurs in the direction of motion. Hence, the *x*-direction is the only affected direction. **A**, **C** and **D** are incorrect. These options show dimensions where either the *x*-direction is not affected, or where the other directions are affected.

Question 10 A

$$P = \frac{E}{t}$$

$$E = P \times t$$

$$= 3.8 \times 10^{26} \times 1$$

$$= 3.8 \times 10^{26} \text{ J}$$

$$E = mc^2$$

$$3.8 \times 10^{26} = m(3.0 \times 10^8)^2$$

$$m = 4.2 \times 10^9 \text{ kg s}^{-1}$$

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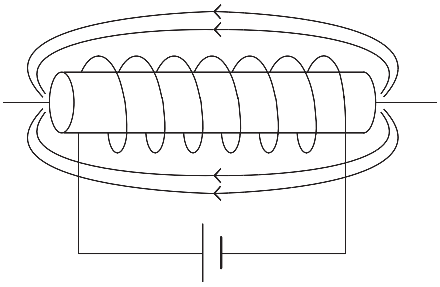
SECTION B

Question 1 (2 marks)



2 marks
1 mark for the correct shape.
1 mark for the correct direction.
Note: Deduct 1 mark for responses that show field lines touching or crossing each other, or for field lines that touch the ends of the core.

Question 2 (6 marks)

Electric field strength at point X due to the +200 μC charge:

$$E = \frac{8.99\times10^9\times200\times10^{-6}}{(0.100)^2}$$ 1 mark

$$= 1.80\times10^8\text{ N C}^{-1}\text{ to the right}$$ 1 mark

Electric field strength at point X due to the –500 μC charge:

$$E = \frac{8.99\times10^9\times500\times10^{-6}}{(0.100)^2}$$ 1 mark

$$= 4.50\times10^8\text{ N C}^{-1}\text{ to the right}$$ 1 mark

$$E_\text{T} = 6.29\times10^8\text{ N C}^{-1}$$ 1 mark

direction = right 1 mark

Question 3 (3 marks)

The force of gravity points downward and has a magnitude of *mg*. The electrical force acting on the mass has magnitude *F* = *qE*, where *q* is the charge of the object and *E* is the magnitude of the electric field. The net force is zero.

$$F_E = F_g$$

$$qE = mg$$ 1 mark

$$25.0\times10^{-6}\times500 = m\times9.8$$ 1 mark

$$m = 1.3\times10^{-3}\text{ kg}$$ 1 mark

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Question 4 (7 marks)

a. $R_{\text{orbit}} = 6.40\times10^6 + 250.0\times10^3$

$= 6.65\times10^6$ m — 1 mark

b. $T = \sqrt{\dfrac{4\pi^2 r^3}{GM}}$ — 1 mark

$= \sqrt{\dfrac{4\pi^2(6.65\times10^6)^3}{6.67\times10^{-11}\times5.98\times10^{24}}}$ — 1 mark

$= 5386$ s — 1 mark

$= 5.40\times10^3$ s (to 3 significant figures) — 1 mark

Note: Consequential on answer to ***Question 4a.***

c. The force of gravity is constant in magnitude and the only force acting on the satellite. — 1 mark

The force of gravity is centre-seeking. — 1 mark

Question 5 (8 marks)

a. $F = nBIl$

$= 75\times2.5\times10^{-1}\times4.0\times0.04$ — 1 mark

$= 0.30$ N — 1 mark

b. equal to the force calculated in **part a.** — 1 mark

The force has the same magnitude and direction due to the wire being within and perpendicular to the field, with length and current unchanged (only the turning effect would change). — 1 mark

Note: Consequential on answer to ***Question 5a.***

c. The split-ring commutator reverses the direction of the current through the coil every half turn. — 1 mark

This then reverses the direction of the force on each side every half turn, and therefore keeps the coil rotating in a constant direction. — 1 mark

d. Using the right-hand slap rule, the force on AB is downwards and the force on CD is upwards. — 1 mark

This causes an anticlockwise rotation of the coil when viewed from the split-ring commutator. — 1 mark

Question 6 (8 marks)

a. $\Phi = B\times A$

$= 0.20\times\pi(0.15)^2$ — 1 mark

$= 1.4\times10^{-2}$ Wb — 1 mark

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b. $\Phi = 0.0$ Wb — 1 mark

c. $\text{EMF} = \dfrac{n\Delta\Phi}{\Delta t}$

$= \dfrac{10(1.4\times10^{-2})}{0.5}$ — 1 mark

$= 2.8\times10^{-1}$ Wb — 1 mark

Note: Consequential on answer to ***Question 6a.***

d. The coil has a reducing area, hence a reducing flux into the page. Therefore, there is a change in flux. — 1 mark

To oppose the change in flux, induce a current such that it induces a field into the page. — 1 mark

The direction is clockwise, as found using the right-hand grip rule or similar. — 1 mark

Question 7 (11 marks)

a. step-up transformer — 1 mark

A step-up transformer will step up the voltage and step down the current for the same power, since $V_2 = \dfrac{N_2}{N_1}\times V_1$. — 1 mark

Stepping down the current will reduce power loss in the transmission lines ($P_{\text{loss}} = I^2 r$). — 1 mark

b. Iron is a very good conductor of magnetic field. — 1 mark

The core links the flux change from the primary to the secondary coil to reduce the flux. — 1 mark

c. $\dfrac{\text{number of turns in the secondary coil}}{\text{number of turns in the primary coil}} = \dfrac{V_\text{s}}{V_p}$

$= \dfrac{275}{20}$ — 1 mark

$= 13.75$

≈ 14 — 1 mark

d. $P = V\times I$

$0.50\times10^{9} = 275\times10^{3}\times I$ — 1 mark

$I = 1820$

$= 1.8\times10^{3}$ A — 1 mark

e. $P_{\text{loss}} = (1820)^2\times5$ — 1 mark

$= 1.6\times10^{7}$ W — 1 mark

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Question 8 (2 marks)

work done = area under graph

$= 4.0 \times 4.0 + \frac{1}{2} \times 2.0 \times 4.0$ 1 mark

$= 20 \text{ J}$ 1 mark

Question 9 (5 marks)

a. $F_{\text{net}} = \frac{mv^2}{r}$

$F_N + F_W = \frac{mv^2}{r}$

$F_N = 0$

$mg = \frac{mv^2}{r}$ (cancel out m)

$v = \sqrt{rg}$ 1 mark

$9.8 = \frac{v^2}{8}$

$v = 8.9 \text{ m s}^{-1}$ 1 mark

b. $E_{\text{total at A}} = E_{\text{total at B}}$ 1 mark

$\frac{1}{2}m(8.9)^2 + m \times 9.8 \times 16.0 = m + 9.8 + h$ (cancel out m) 1 mark

$h = 20.0 \text{ m}$ 1 mark

Question 10 (5 marks)

Time to travel 70.0 m:

$\text{speed} = \frac{\text{distance}}{\text{time}}$

$\text{time} = \frac{70.0}{30.0 \cos 45.0}$ 1 mark

$= 3.2 \text{ s}$ 1 mark

Vertical displacement:

$u = 30.0 \sin 45.0$

$= 21.2 \text{ m s}^{-2}$

$a = g = -9.8 \text{ m s}^{-2}$

$s = ut + \frac{1}{2}at^2$

$= 21.2 \times 3.2 + \frac{1}{2} \times -9.8(3.2)^2$ 1 mark

$= 17.7$ above initial displacement 1 mark

Therefore, the batter scores six runs. 1 mark

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Question 11 (8 marks)

a. $m_1\boldsymbol{u}_1 + m_2\boldsymbol{u}_2 = m_1\boldsymbol{v}_1 + m_2\boldsymbol{v}_2$

$8.0(16) + 0 = 8.0 \times (-4.0) + 16 \times v_2$ 1 mark

$\boldsymbol{v}_2 = 10 \text{ m s}^{-1}$ 1 mark

b. $I = m\Delta v$

$= 8.0(-4 - 16)$ 1 mark

$= -160$

$I = 1.6 \times 10^2$ (to 2 significant figures) 1 mark

direction = left 1 mark

c. $E_\text{k} \text{ before} = \frac{1}{2}m_1(\boldsymbol{u}_1)^2 + \frac{1}{2}m_2(\boldsymbol{u}_2)^2$

$= \frac{1}{2}8.0(16)^2 + \frac{1}{2}16(0)^2$

$= 1024 \text{ J}$ 1 mark

$E_\text{k} \text{ after} = \frac{1}{2}m_1(\boldsymbol{v}_1)^2 + \frac{1}{2}m_2(\boldsymbol{v}_2)^2$

$= \frac{1}{2}8.0(-4.0)^2 + \frac{1}{2}16(10)^2$

$= 864 \text{ J}$ 1 mark

$\frac{1}{2}m_1(\boldsymbol{u}_1)^2 + \frac{1}{2}m_2(\boldsymbol{u}_2)^2 > \frac{1}{2}m_1(\boldsymbol{v}_1)^2 + \frac{1}{2}m_2(\boldsymbol{v}_2)^2$

inelastic 1 mark

*Note: Consequential on answer to **Question 11a.***

Question 12 (9 marks)

a. U_g top = U_s bottom

$mgh = \frac{1}{2}ks^2$ 1 mark

$h = s$

$5.0 \times 9.8 \times s = \frac{1}{2} \times 100.0 \times s^2$ (cancel out s) 1 mark

$5.0 \times 9.8 = \frac{1}{2} \times 100.0 \times s$

$s = 0.98 \text{ m}$ 1 mark

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b. $U_g = mgh$ at the top position is equal to total energy of the mass–spring system.

$U_g = 5.0 \times 9.8 \times 0.98$

$E_T = 48.02 \text{ J}$ 1 mark

At the midpoint:

$E_T = U_g + U_s + E_k$

$48.08 = 5.0 \times 9.8 \times \left(\frac{0.98}{2}\right) + \frac{1}{2} \times 100.0 \times \left(\frac{0.98}{2}\right)^2 + \frac{1}{2} \times 5.0 \times v^2$ 1 mark

$v = 2.2 \text{ m s}^{-1}$ 1 mark

c. graph III 1 mark

For example:

Let downwards be positive.

At the top, the spring extension (Δx) is 0 and $F_{net} = mg$, so $a_{net} = g$ down. 1 mark

In the middle, $F_{net} = mg - k(\Delta x) = 0$, so $a_{net} = 0$.

At the lowest point, using energy conservation:

$$mg(\Delta x) = \frac{1}{2} k (\Delta x)^2$$

$$(\Delta x) = 2\frac{mg}{k}$$

$$\begin{aligned} F_{net} &= mg - k(\Delta x) \\ &= mg - k\left(\frac{2mg}{k}\right) \\ &= mg - 2mg \\ &= -mg \end{aligned}$$

Therefore, $a_{net} = g$ up. 1 mark

Question 13 (6 marks)

a. $$\gamma = \frac{1}{\sqrt{1 - \frac{(0.999c)^2}{c^2}}}$$

$= 22.37$ 1 mark

$t = t_0 \gamma$

$= 2.20 \times 22.37$ 1 mark

$= 49.2 \ \mu\text{s}$ 1 mark

b. No. 1 mark

As the stationary observer sees the event move past them, they measure the dilated time. 1 mark

The muon is at rest relevant to the event, so it measures the proper time. 1 mark

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