

Trial Examination 2020

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

Question 1 D

The field lines travel from North to South, and so the direction of the field is to the left.

Question 2 B

If the speed is decreased, the radius of the path will decrease, as shown by $r = \frac{mv}{q_e B}$. If the velocity has decreased, then the force acting on the proton will decrease, as shown by $F_c = qvB$.

Question 3 D

$$\begin{aligned} F_{\text{new}} &= \frac{k2Q2Q}{\left(\frac{r}{2}\right)^2} \\ &= 4 \times (2)^2 \times F_{\text{original}} \\ &= 16 \times F_{\text{original}} \end{aligned}$$

Question 4 D

$$\begin{aligned} \frac{r_{\text{Rhea}}^3}{t_{\text{Rhea}}^2} &= \frac{r_{\text{Helene}}^3}{t_{\text{Helene}}^2} \\ \frac{(527.1)^3}{(4.5)^2} &= \frac{(377.4)^3}{t^2} \\ t &= \sqrt{\frac{(527.1)^3 \times (4.5)^2}{(377.4)^3}} \\ &= 7.4 \text{ days} \end{aligned}$$

Question 5 B

Because of the orientation, the primary side is on the right and the secondary side is on the left.

$$\begin{aligned} \frac{N_{\text{primary}}}{N_{\text{secondary}}} &= \frac{V_{\text{primary}}}{V_{\text{secondary}}} \\ \frac{6}{12} &= \frac{12}{V_{\text{secondary}}} \\ V_{\text{secondary}} &= 24.0 \text{ V} \end{aligned}$$

Question 6 C

Graph C best represents the induced EMF, as EMF is proportional to the rate of change of flux.

Question 7 C

The vertical component of speed is 0.0 m s^{-1} and the horizontal component is $70.0\cos30 = 60.6 \text{ m s}^{-1}$. Speed at P is therefore $70.0\cos30 = 60.6 \text{ m s}^{-1}$.

Question 8 C

$$F_{\text{net}} = ma$$

$$10 = (3.0 + 2.0)a$$

$$a = 2.0 \text{ m s}^{-2}$$

$$T = 2.0 \times 3.0$$

$$= 6.0 \text{ N}$$

Question 9 D

$$u = 0.0, s = 16.0 \text{ and } t = 16.0.$$

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

$$16.0 = 0.0 + \frac{1}{2}a(16.0)^2$$

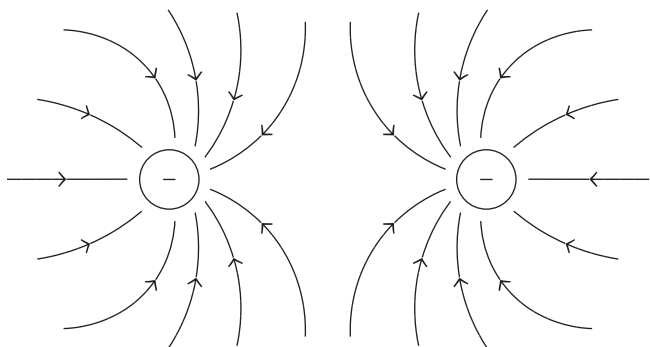
$$a = 0.125 \text{ m s}^{-2}$$

$$1.0 \times 0.125 = 1.0 \times 9.8 \sin 15 - F$$

$$F = 2.4 \text{ N}$$

Question 10 A

The speed of light is always c . The invariance of the speed of light is one of the postulates of special relativity.

SECTION B**Question 1** (2 marks)

2 marks

*1 mark for the correct shape.
1 mark for the correct direction.*

Question 2 (7 marks)

- a. Since the velocity of the charge is at right angles to the field, the force will be at right angles to the velocity. 1 mark
 The magnitude of the force remains constant regardless of the direction of the charge. 1 mark
- b. electron 1 mark
 Use the right-hand slap rule, Fleming's left-hand rule or equivalent. 1 mark
 The thumb is pointing south, fingers into page and palm to the east. This provides the centre-seeking force for circular motion in the clockwise direction. 1 mark
- c. $F = vBq$
 $= 1.0 \times 10^6 \times 0.3 \times 1.6 \times 10^{-19}$ 1 mark
 $= 4.8 \times 10^{-14} \text{ N}$ 1 mark

Question 3 (7 marks)

- a. $E = \frac{\Delta V}{d}$
 $= \frac{2.00 \times 10^2}{5.00 \times 10^{-3}}$ 1 mark
 $= 4.00 \times 10^4 \text{ V m}^{-1}$ 1 mark
- b. $F = qE$
 $= 1.5 \times 10^{-6} \times 4.00 \times 10^4$ 1 mark
 $= 0.060 \text{ N}$ 1 mark
 The direction is down. 1 mark

c. $W = Fs$

$$= 0.06 \times 2.50 \times 10^{-3} \quad 1 \text{ mark}$$

$$= 1.50 \times 10^{-4} \text{ J} \quad 1 \text{ mark}$$

Question 4 (3 marks)

$$F_{\text{right}} = \frac{kQ_1Q_2}{r^2}$$

$$= \frac{9.0 \times 10^9 \times 5.0 \times 10^{-6} \times 10.0 \times 10^{-6}}{2.0^2}$$

$$= 0.11 \text{ N} \quad 1 \text{ mark}$$

$$F_{\text{left}} = \frac{9.0 \times 10^9 \times 5.0 \times 10^{-6} \times 10.0 \times 10^{-6}}{1.0^2}$$

$$= 0.45 \text{ N} \quad 1 \text{ mark}$$

$$F_{\text{net}} = 0.34 \text{ N left} \quad 1 \text{ mark}$$

Question 5 (9 marks)

a. 0 N kg^{-1} 1 mark

The gravitational field vectors from all parts of the mass of Mars point to the centre. 1 mark

These vectors sum to zero. 1 mark

b. $24 \times 60 + 37 = 1477 \text{ min}$
 $= 88\,620 \text{ s}$ 1 mark

c. $R = \sqrt[3]{\frac{GMT^2}{4\pi^2}}$ 1 mark

$$= \sqrt[3]{\frac{6.67 \times 10^{-11} \times 6.4 \times 10^{23} \times (88\,620)^2}{4\pi^2}}$$
 1 mark

$$= 2.0 \times 10^7 \text{ m} \quad 1 \text{ mark}$$

d. gravity 1 mark

e. The direction of net force is towards the centre of Mars. 1 mark

Question 6 (5 marks)

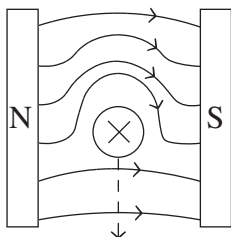
a. $F_{AB} = nBIl$

$$= 100 \times 0.020 \times 0.50 \times 0.10 \quad 1 \text{ mark}$$

$$= 0.10 \text{ N} \quad 1 \text{ mark}$$

b. $F_{BC} = 0 \text{ N}$ 1 mark

- c. There is a force on the side AB in the position shown because the coil's current travels at right angles to the external magnetic field. 1 mark
- By the right-hand rule, the force is downwards on side AB. 1 mark



Note: A diagram that supports the response is acceptable, but not required for the mark.

Question 7 (8 marks)

- a. Y to X 1 mark
- Change: There is an increasing south field into the coil, therefore a change in flux in the coil. 1 mark
- Oppose: A current is induced such that it creates a field with south pole to the left of the coil to oppose the changing in flux of increasing south into the coil. 1 mark
- Using the right-hand grip rule, the induced current is from Y to X through the resistor. 1 mark
- b. There is no current produced. 1 mark
- As there is no changing flux, there is therefore no EMF/current induced in the coil. 1 mark
- c. *For example, any two of:*
- Use more coils.
 - Use a stronger bar magnet.
 - Move the magnet faster relative to the coil.
 - Use an iron core.
 - Use wires of less resistance.

2 marks

Question 8 (10 marks)

- a. $\frac{\text{number of turns on the secondary}}{\text{number of turns on the primary}} = \frac{\text{voltage of secondary}}{\text{voltage of primary}}$
- $$= \frac{500}{20}$$
- 1 mark
- $$= 25$$
- 1 mark
- b. $P = V \times I$
- $$200 \times 10^6 = 500 \times 10^3 \times I$$
- 1 mark
- $$I = 400 \text{ A}$$
- 1 mark

- c. $V_{\text{drop}} = I \times R_{\text{lines}}$
 $= 500 \times 10^3 - 495 \times 10^3$ 1 mark
 $= 5 \times 10^3$
 $= 400 \times R_{\text{lines}}$ 1 mark
 $R_{\text{lines}} = 12.5 \, \Omega$ 1 mark
- d. Powerlines have electrical resistance, so the lines use up some of the supplied voltage.
 This dissipates power: $P_{\text{loss}} = I^2 r$, so $P_{\text{loss}} \propto I^2$. 1 mark
 Since $P = VI$, a fixed amount of power of $200 \times 10^6 \, \text{W}$ can be transmitted at higher voltages to reduce the amount of current flowing through the transmission lines. 1 mark
 Reducing the current in the lines by raising the transmission voltage reduces the power loss in the lines while maintaining the power transmitted. 1 mark

Question 9 (5 marks)

- a. $v = 34.7 \sin(81.7)$
 $= 34.3$ 1 mark
 $u = 0, a = g = 9.8 \, \text{m s}^{-2}$
 $v = u + at$
 $34.3 = 0 + 9.8t$ 1 mark
 $t = 3.5 \, \text{s}$ 1 mark
- b. distance = speed $\times$ time
 $= 34.7 \cos 81.7 \times 3.5$ 1 mark
 $= 17.5 \, \text{m}$ 1 mark

*Note: Consequential on answer to Question 9a.***Question 10** (6 marks)

- a. $m_1 u_1 + m_2 u_2 = m_1 v_1 + m_2 v_2$
 $0.2 \times 20.0 + 0.0 = (0.2 + m) \times 5.0$ 1 mark
 $m = 0.6 \, \text{kg}$ 1 mark
 $m = 600 \, \text{g}$ (as required) 1 mark

- b. $E_{K(\text{before})} = \frac{1}{2}m_1(u_1)^2 + \frac{1}{2}m_2(u_2)^2$
 $= \frac{1}{2}0.2(20.0)^2 + 0.0 = 40 \text{ J}$ 1 mark
- $E_{K(\text{after})} = \frac{1}{2}0.2(\mathbf{5.0})^2 + \frac{1}{2}0.6(\mathbf{5.0})^2 = 10 \text{ J}$ 1 mark
- $\frac{1}{2}m_1(u_1)^2 + \frac{1}{2}m_2(u_2)^2 > \frac{1}{2}m_1(v_1)^2 + \frac{1}{2}m_2(v_2)^2$
 inelastic 1 mark

Question 11 (7 marks)

- a. $U_s = \frac{1}{2} \times 200.0(2.00 - 1.5)^2$ 1 mark
 $= 25.0 \text{ J as required}$ 1 mark
- b. The ball reaches maximum speed when the net force is zero and the ball has stopped accelerating.
 $mg = kx$
 $2.0 \times 9.8 = 200.0x$ 1 mark
 $x = 0.098 = 0.10 \text{ m}$ 1 mark
- c. $E_T = 25.0 \text{ J}$
 When launched, the ball has $U_g + E_K$. 1 mark
 $25.0 = 2 \times 9.8 \times 0.5 + \frac{1}{2}2 \times v^2$ 1 mark
 $v = 3.9 \text{ m s}^{-1}$ 1 mark

Question 12 (5 marks)

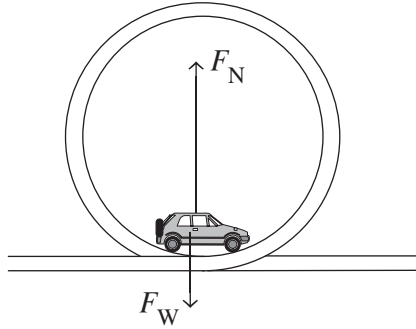
- a. minimum speed needed to maintain contact:

$$g = \frac{v^2}{r}$$

$$v = \sqrt{9.8 \times 12}$$
 1 mark
$$= 10.8 \text{ m s}^{-1}$$
 1 mark

If the car is travelling at 8.0 m s^{-1} when it reaches the top of the loop it will not remain in contact with the track. 1 mark

b.



2 marks

*1 mark for labelled force vectors.**1 mark for relative length of force vectors.***Question 13** (4 marks)

a. time dilation

1 mark

b. $l = \frac{l_o}{\gamma}$

$$\gamma = \frac{5.0}{2.2} = 2.27$$

1 mark

$$v = c \sqrt{1 - \frac{1}{\gamma^2}}$$

$$= 3.0 \times 10^8 \sqrt{1 - \frac{1}{2.27^2}}$$

1 mark

$$= 2.7 \times 10^8 \text{ m s}^{-1}$$

1 mark

Question 14 (2 marks)

The work done is equal to the change in kinetic energy.

$$\Delta E_K = (\gamma - 1)m_0 c^2$$

$$= (3.2 - 1) \times 9.1 \times 10^{-31} \times (3.0 \times 10^8)^2$$

1 mark

$$= 1.8 \times 10^{-13} \text{ J}$$

1 mark