Neap:

Trial Examination 2017

VCE Physics Unit 3

Written Examination

Suggested Solutions

Neap Trial Exams are licensed to be photocopied or placed on the school intranet and used only within the confines of the school purchasing them, for the purpose of examining that school's students only. They may not be otherwise reproduced or distributed. The copyright of Neap Trial Exams remains with Neap. No Neap Trial Exam or any part thereof is to be issued or passed on by any person to any party inclusive of other schools, non-practising teachers, coaching colleges, tutors, parents, students, publishing agencies or websites without the express written consent of Neap.

Copyright © 2017 Neap ABN 49 910 906 643 58 Pelham St Carlton VIC 3053 Tel: (03) 9639 4318 Fax: (03) 8610 0090 PHYU3_SS_2017.FM

SECTION A – MULTIPLE-CHOICE QUESTIONS

Question 1 **B**

Charge Q is positive and the direction of the electric field between P and Q is to the left, hence **B** is the correct response.

Question 2 **A**

$$\frac{g_{\text{Mars}}}{g_{\text{Earth}}} = \frac{\left(\dfrac{GM_{\text{Mars}}}{(r_{\text{Mars}})^2}\right)}{\left(\dfrac{GM_{\text{Earth}}}{(r_{\text{Earth}})^2}\right)}$$

$$= \frac{GM_{\text{Mars}}}{(r_{\text{Mars}})^2} \times \frac{(r_{\text{Earth}})^2}{GM_{\text{Earth}}} \qquad (G\ \textit{cancels})$$

$$\frac{M_{\text{Mars}}}{M_{\text{Earth}}} = \frac{g_{\text{Mars}}(r_{\text{Mars}})^2}{g_{\text{Earth}}(r_{\text{Earth}})^2}$$

$$= \frac{0.4 \times g_{\text{Earth}}(0.5 \times r_{\text{Earth}})^2}{g_{\text{Earth}}(r_{\text{Earth}})^2}$$

$$= 0.4 \times (0.5)^2$$

$$M_{\text{Mars}} = 0.1 \times M_{\text{Earth}}$$

Question 3 **C**

Use the right hand slap rule and reverse the direction because it is an electron.

Question 4 **A**

$E = \frac{V}{d}$ where V is the potential difference between the plates and d is the distance between the plates. Both V and d are constant, and hence so is E.

Question 5 **D**

The period has doubled and the EMF is halved. That is, period $= \frac{1}{\text{frequency}}$, frequency is now halved so the period is doubled.

$\text{EMF} \times \frac{\Delta\phi}{\Delta t}$, since Δt is doubled, EMF is halved.

 PHYU3_SS_2017.FM Copyright © 2017 Neap

Question 6 **A**

$V_P = \sqrt{2} \times 28.3$

$= 40 \text{ V}$

$T = 40 \text{ ms}$

$= 0.04 \text{ s}$

$f = \dfrac{1}{0.04}$

$= 25 \text{ Hz}$

Question 7 **D**

Constant velocity is a non-accelerating frame of reference, hence **D** is correct.

Question 8 **D**

$F_{net} = N - W$

$N = F_{net} + W$

$= \dfrac{mv^2}{r} + mg$

$= \dfrac{120 \times (2)^2}{2} + 120 \times 10$

$= 1440 \text{ N}$

Question 9 **B**

$F_{net} = ma$

$T - f = ma$

$T - 500 = 1000 \times 0.5$

$T = 1000 \text{ N}$

Question 10 **B**

$GPE_{top} = EPE_{bottom}$

$mgh = \dfrac{1}{2}kx^2$

$0.2 \times 9.8 \times h = \dfrac{1}{2} \times 9.8 \times x^2 \qquad (h = x)$

$\dfrac{1}{2} \times 10 \times x = 0.2 \times 10$

$x = 0.4 \text{ m}$

$= 40 \text{ cm}$

Copyright © 2017 Neap

SECTION B – SHORT-ANSWER QUESTIONS

Question 1 (3 marks)

a. The two charged particles have opposite charges and so the magnetic force acting on each is in the opposite direction. 1 mark

b. Since $r = \frac{mr}{Bq}$, the different masses, speeds and particle changes lead to different values. 1 mark

The paths are circular because the force produced by the magnetic field on the moving charge is constant in magnitude and always perpendicular to the particles' velocities. 1 mark

Question 2 (4 marks)

a.

$$F = BIL\sin\theta$$

$$0.00202 \times 10 = B \times 1.5 \times 0.02\sin 90$$ 1 mark

$$B = 0.67\ \text{T}$$ 1 mark

b. The pole facing the rod is north. 1 mark
(right-hand slap/palm rule) 1 mark

Question 3 (5 marks)

a. As the magnet enters the copper tube, there is a change in external flux, and hence an EMF is induced while flux goes from minimum to maximum. 1 mark

While travelling through the long tube, the flux is maximum and not changing, hence there is no EMF induced in the tube. 1 mark

As the magnet leaves the copper tube, there is a change in external flux, and hence an EMF is induced as the flux goes from maximum to minimum. 1 mark

A changing flux induces an EMF according to Faraday's Law. 1 mark

b. **A.** 1 mark

EMF is induced as the magnet enters. Then no EMF passes through the pipe. After this, the magnet EMF of opposite polarity (Lenz's law) emerges.

Question 4 (7 marks)

a. motor effect 1 mark

The wire PQ experiences a force because of the interaction between the magnetic field provided by the permanent magnet (for example, the north and south poles on either side of the coil) and the electric current in the coil. This force is maximum when the wire is at right angles to the magnetic field. 1 mark

 PHYU3_SS_2017.FM Copyright © 2017 Neap

b. It is a split ring commutator which ensures that the coil will rotate in one direction by reversing the current, and hence the force, on each individual side every cycle rotation when the coil is at right angles to the magnetic field (and the current stops momentarily). 1 mark

At this point, despite the cessation of the torque, the coil continues to turn due to its momentum and then the current flows again and the torque is reinstated in the same rotational direction. 1 mark

The commutator and the brushes form a mechanical switch. 1 mark

c. **B.** 1 mark

The magnitude of the force on PQ does not change (however the torque does and it decreases). 1 mark

Question 5 (11 marks)

a.

$$P = V \times I$$

$$120 \times 10^6 = 24 \times 10^3 \times I \quad \text{1 mark}$$

$$I = 5000\ \text{A} \quad \text{1 mark}$$

b.

$$\frac{N_P}{N_S} = \frac{I_S}{I_P}$$

$$\frac{24\ \text{kV}}{240\ \text{kV}} = \frac{I_S}{5000} \quad \text{1 mark}$$

$$I_S = 500\ \text{A} \quad \text{1 mark}$$

c.

$$V_{drop} = I \times R$$

$$= 500 \times 2$$

$$= 1000\ \text{V} \quad \text{1 mark}$$

$$V_2 = 240\,000 - 1000 \quad \text{1 mark}$$

$$= 239\,000\ \text{V}$$

$$= 239\ \text{kV} \quad \text{1 mark}$$

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

d. Transformers will only operate on AC input voltages – not constant DC voltages. 1 mark

Transformers work on electromagnetic induction. 1 mark

A voltage, or EMF, can only be induced in the secondary coil of a transformer if there is a change in flux. 1 mark

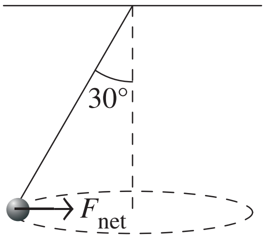
AC electricity produces an alternating flux in a transformer's primary coils, resulting in induced AC flux and voltage in the secondary coil. This provides a changing magnetic flux, $\Delta\phi$ in the primary coil, allowing an EMF to be induced in the secondary coil. 1 mark

Question 6 (7 marks)

a. **B.** 1 mark

Copyright © 2017 Neap

b.



1 mark

c. $\cos 30° = \frac{1.5 \times 9.8}{T}$

$T = 16.97$ 1 mark

$= 17$ N 1 mark

d. $\tan 30 = \frac{\left(\frac{mv^2}{r}\right)}{mg}$ 1 mark

$= \frac{mv^2}{r} \times \frac{1}{mg}$ (m cancels)

$0.5 \times 10 \tan\theta = v^2$ 1 mark

$v = 1.7$ m s^{-1} 1 mark

Question 7 (6 marks)

a. $v_{horizontal} = \frac{20.0}{1.53}$

$= 13.07$

$= 13.1$ m s^{-1} 1 mark

$\cos 30 = \frac{13.1}{U}$

$u = \frac{13.1}{\cos 30}$

$= 15.1$ m s^{-1} 1 mark

b. $v_{horizontal} = 13.1$ m s^{-1} 1 mark

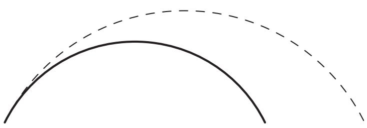
$v_{vertical} = 0$ m s^{-1}

Therefore, speed = 13.1 m s^{-1}. 1 mark

c. **D.** vertically down (10 m s^{-2}) 1 mark

If air resistance is ignored, the only force acting on the projectile is the force due to gravity. This force is constant and is always directed vertically downwards.

d.



1 mark

maximum height is smaller, range is shorter

 Copyright © 2017 Neap

Question 8 (8 marks)

a. $m_1u_1 + m_2u_2 = m_1v_1 + m_2v_2$

$(1.2 \times 0.5) + (1.4 \times -0.2) = (1.2 \times -0.1) + 1.4v_2$ 1 mark

$v_2 = 0.3 \text{ m s}^{-1}$ 1 mark

b. $E_{\text{K before}} = \frac{1}{2}m_1(u_1)^2 + \frac{1}{2}m_2(u_2)^2$

$= \frac{1}{2} \times 1.2 \times (0.5)^2 + \frac{1}{2} \times 1.4 \times (-0.2)^2$

$= 0.18 \text{ J}$ 1 mark

$E_{\text{K after}} = \frac{1}{2}m_1(v_1)^2 + \frac{1}{2}m_2(v_2)^2$

$= \frac{1}{2} \times 1.2 \times (-0.1)^2 + \frac{1}{2} \times 1.4 \times (0.3)^2$

$= 0.07 \text{ J}$ 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

c. area = $m\Delta v$ 1 mark

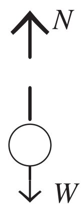
$\frac{1}{2} \times 0.050 \times F_{\text{peak}} = 1.2(-0.1 - 0.5)$ 1 mark

$= -28.8 \text{ N}$

$= 28.8 \text{ N west}$ 1 mark

Question 9 (6 marks)

a.



2 marks

Note: For both marks, the normal force must be vertical upwards and it must be significantly bigger than the weight force, so there is a non-zero net force upwards.

b. Step 1: Calculate the velocity of the ball as it hits the ground.

$v^2 = u^2 + 2as$

$= 0^2 + 2 \times 10 \times 2.5$

$v = 7.1 \text{ m s}^{-1}$ 1 mark

Step 2: Calculate the velocity of the ball as it leaves the ground.

$v^2 = u^2 + 2as$

$0^2 = u^2 + 2 \times -10 \times 1.5$

$u = 5.5 \text{ m s}^{-1}$ 1 mark

Step 3: impulse = change in momentum

$= mv - mu$ (taking upwards as positive) 1 mark

$= 0.2(5.5 - (-7.1))$

$= 2.52$

$= 2.5 \text{ N s or } 2.5 \text{ kg m s}^{-1}$ 1 mark

Question 10 (5 marks)

a. Acceleration is equal in magnitude as it moves as a system. Tension is also equal in magnitude as it moves as a system.

For 2 kg mass, taking upwards as positive,

$T - W = ma$

$T - 2 \times 10 = 2a$

$T = 2a + 20.0$ (substitute into other equation) 1 mark

For 5 kg mass, taking downwards as positive,

$W - T = ma$

$5 \times 10 - T = 5a$ 1 mark

$50.0 - (2a + 20) = 5a$

$30.0 = 7a$

$a = 4.3 \text{ m s}^{-2}$ 1 mark

b. $u = 0 \text{ m s}^{-1}$, $s = 1.0 \text{ m}$, $a = 4.3 \text{ m s}^{-2}$, $t = ?$

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

$1.0 = 0 + \frac{1}{2} \times 4.2t^2$ 1 mark

$t = 0.68 \text{ s}$ 1 mark

Note: Consequential on answer to ***Question 10a.***

  Copyright © 2017 Neap

Question 11 (5 marks)

a. time = $(24 \times 60 \times 60) + (39 \times 60) + 35$ 1 mark

$= 88\,775$ s 1 mark

b. $r = \sqrt[3]{\dfrac{GMT^2}{4\pi^2}}$ 1 mark

$= \sqrt[3]{\dfrac{(6.67 \times 10^{-11}) \times (6.4 \times 10^{23}) \times (88\,775)^2}{4\pi^2}}$ 1 mark

$= 2.04 \times 10^7$

$= 2.0 \times 10^7$ m 1 mark

Question 12 (6 marks)

a. $\gamma = \dfrac{1}{\sqrt{1 - \dfrac{v^2}{c^2}}}$

$= \dfrac{1}{\sqrt{1 - \dfrac{(0.995c)^2}{c^2}}}$ 1 mark

$= 10.01$ 1 mark

b. $t = t_0 \gamma$

$= 2.2 \times 10^{-6} \times 10.0$ 1 mark

$= 2.2 \times 10^{-5}$ s 1 mark

c. $l = \dfrac{l_0}{\gamma}$

$= \dfrac{1000}{10.01}$ 1 mark

$= 99.9$ km 1 mark

Copyright © 2017 Neap

Question 13 (7 marks)

a. $E_{\text{total}} = \gamma m_0 c^2$

$$\gamma = \frac{E_{\text{total}}}{E_{\text{rest}}}$$

$$= \frac{100 \times 10^9}{938.3 \times 10^6}$$

$$= 106.5757$$

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

$$106.5757 = \frac{1}{\sqrt{1 - \frac{v^2}{c^2}}}$$

$$\sqrt{1 - \frac{v^2}{c^2}} = \frac{1}{106.5757}$$ 1 mark

$$\frac{v^2}{c^2} = 0.999911959$$ 1 mark

$$v = 0.99996c$$

$$= 99.996\%c$$ 1 mark

b. Particles have a mass, and particles that have a mass require energy to accelerate them. The closer you get to the speed of light, the more energy is needed to increase their speed because the particles themselves increase in relativistic mass. 1 mark

As you approach *c*, the speed of the particle increases slightly while its relativistic mass increases substantially. An infinite amount of energy would be required in order to accelerate the particle to a speed of *c*. 1 mark

Hence, the speed of the particle can never reach the speed of light according to Einstein's theory of special relativity. 1 mark

 PHYU3_SS_2017.FM Copyright © 2017 Neap