



NATIONAL SENIOR CERTIFICATE EXAMINATION
SUPPLEMENTARY EXAMINATION 2015

PHYSICAL SCIENCES: PAPER I

MARKING GUIDELINES

Time: 3 hours

200 marks

These marking guidelines are prepared for use by examiners and sub-examiners, all of whom are required to attend a standardisation meeting to ensure that the guidelines are consistently interpreted and applied in the marking of candidates' scripts.

The IEB will not enter into any discussions or correspondence about any marking guidelines. It is acknowledged that there may be different views about some matters of emphasis or detail in the guidelines. It is also recognised that, without the benefit of attendance at a standardisation meeting, there may be different interpretations of the application of the marking guidelines.

QUESTION 1 MULTIPLE CHOICE

- 1.1 C
- 1.2 B
- 1.3 D
- 1.4 B
- 1.5 A
- 1.6 D
- 1.7 D
- 1.8 A
- 1.9 A
- 1.10 C

[20]

QUESTION 2 KINEMATICS – VECTORS

2.1 Distance is the length of the path travelled. Susie travels the greater distance. (2)

2.2 Displacement is a change in position. Neither (same displacement for Thandi and Susie). (2)

$$\begin{aligned}
 2.3 \quad \text{time}_{AB} &= \frac{\text{distance}_{AB}}{\text{speed}_{AB}} \\
 &= \frac{240}{1,5} \\
 &= 160 \text{ s}
 \end{aligned}$$

$$\begin{aligned}
 \text{Average speed}_{BC} &= \frac{\text{distance}_{BC}}{\text{time}_{BC}} \\
 &= \frac{100}{20} \quad t = 180 \text{ (conversion)} - 160 = 20 \text{ s} \\
 &= 5 \text{ m.s}^{-1}
 \end{aligned} \quad (6)$$

$$2.4 \quad \text{Average speed} = \frac{\text{distance}}{\text{time}} = \frac{240 + 100}{180} = 1,89 \text{ m.s}^{-1} \quad (3)$$

$$\begin{aligned}
 2.5 \quad AC^2 &= 240^2 + 100^2 \\
 AC &= 260 \text{ m} \\
 \text{Average velocity} &= \frac{\text{displacement}}{\text{time}} = \frac{260}{180} = 1,44 \text{ m.s}^{-1} \text{ (c.o.e. no conversion of time)} \\
 \tan \theta &= \frac{100}{240} \quad \text{OR} \quad \sin \theta = \frac{100}{260} \quad \text{OR} \quad \cos \theta = \frac{240}{260} \\
 \theta &= 22,62^\circ \text{ to the bridge OR } 67,38^\circ \text{ to the bank}
 \end{aligned}$$

(5)
[18]

QUESTION 3 KINEMATICS – MOTION

3.1 $83,8 \times 3,6 = 301,68 \text{ km.h}^{-1}$ (method) (accuracy) (2)

3.2 **Method 1**

$$\Delta x = \frac{(v_i + v_f) \cdot t}{2}$$

$$\Delta x = \frac{(0 + 83,3) \cdot 13,63}{2}$$

$$\Delta x = 567,69 \text{ m}$$

Method 2

$$v_f = v_i + at$$

$$83,3 = 0 + a(13,63)$$

$$a = 6,11 \text{ m.s}^{-2}$$

$$v_f^2 = v_i^2 + 2a\Delta x$$

$$83,3^2 = 0^2 + 2(6,11)\Delta x$$

$$\Delta x = 567,83 \text{ m}$$

OR

$$\Delta x = v_i \Delta t + \frac{1}{2} a \Delta t^2$$

$$\Delta x = 0 \cdot (13,63) + \frac{1}{2} (6,11)(13,63)^2$$

$$\Delta x = 567,55 \text{ m} \quad (4)$$

- 3.3 3.3.1 Reaction distance is directly proportional to speed. (2)
OR As speed increases the reaction distance increases.
OR Reaction distance = $0,7 \times \text{speed}$

3.3.2 $v_f^2 = v_i^2 + 2a\Delta x$
 $0 = v_i^2 + 2a\Delta x$
 $\Delta x = \frac{-v_i^2}{2a}$
 $\Delta x = k \cdot v_i^2 \left(\text{where } k = -\frac{1}{2a} \right) \quad (2)$

3.3.3

(Initial) speed (m.s^{-1}) v_i	Braking distance (m) Δx	$k = \frac{\Delta x}{v_i^2}$
10	7	$k = 7 / 10^2 = 0,07$
20	28	$k = 28 / 20^2 = 0,07$
30	63	$k = 63 / 30^2 = 0,07$
40	112	$k = 112 / 40^2 = 0,07$

Calculating constant (k) for 2 pairs of values
 Calculating constant for 3 or 4 pairs of values (4)

- 3.3.4 (a) Mental state of driver/tiredness/alcohol consumption (ONE only) (1)
 (b) Road surface (oil/ice/wet); state of tyres (worn/good tread); state of brakes (ONE) (1)

3.4 **Reaction distance**

$$\Delta x = v_i \Delta t + \frac{1}{2} a \Delta t^2 \quad (a = 0)$$

$$= 113 \times 0,7$$

$$= 79,1 \text{ m}$$

$$\Delta x = 527,64 \text{ m}$$

Total distance = ~~79,1~~ + 527,64 = **606,74 m** $\therefore$ **he does NOT stop in time.**

Braking distance

$$v_f^2 = v_i^2 + 2a\Delta x$$

$$0^2 = 113^2 + 2(-12,1)\Delta x$$

OR He must stop in $(600 - 79,1) = 520,9 \text{ m}$ from when he starts braking.
 $\therefore$ **he does NOT stop in time.**

OR He must stop in $(600 - 79,1) = 520,9 \text{ m}$ from when he starts braking.

$$v_f^2 = v_i^2 + 2a\Delta x$$

$$= 113^2 + 2(-12).520,9$$

$$v_f = 12,78 \text{ m.s}^{-1}$$

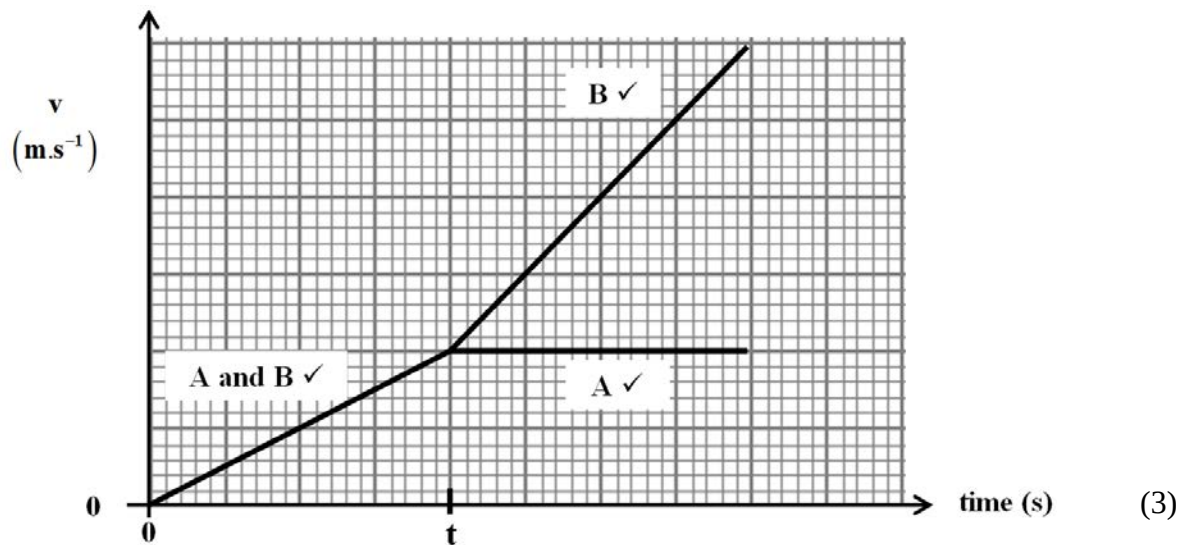
He is still moving at $12,78 \text{ m.s}^{-1}$ when he reaches the tree $\therefore$ **he does NOT stop in time.**

(6)

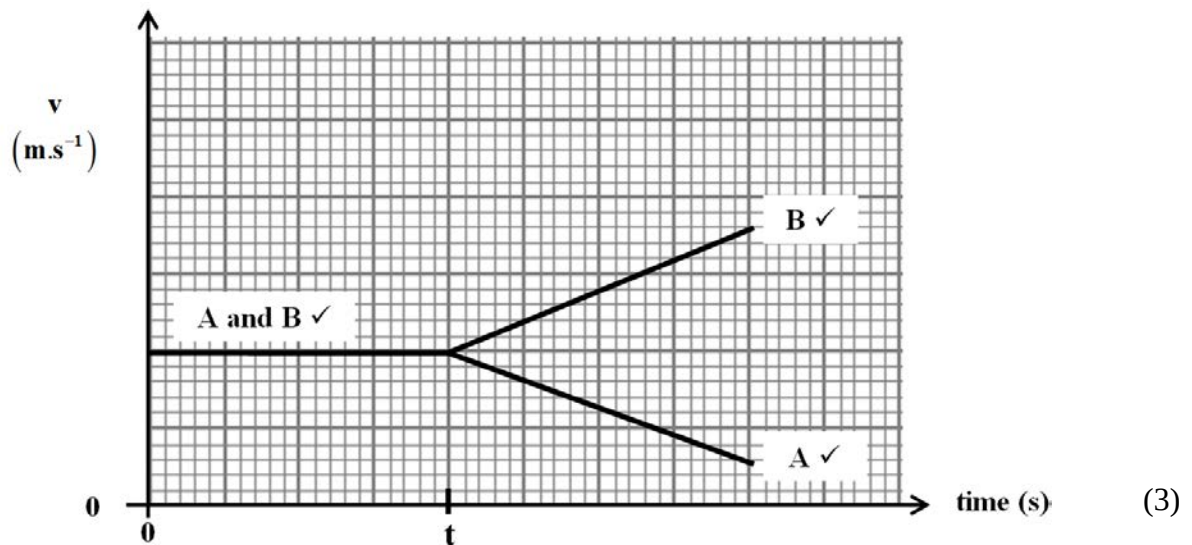
[22]

QUESTION 4 NEWTON'S LAWS

4.1 Answer sheet



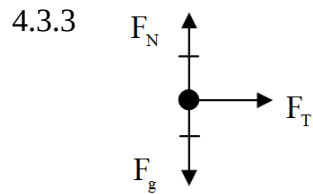
4.2 Answer sheet



- 4.3 4.3.1 **Newton's second law:** When a net force (F_{net}) is applied to an object (of mass) it accelerates in the direction of the net force. The acceleration (a) is directly proportional to the net force and inversely proportional to the mass.

OR The net force acting on a body is equal to (or directly proportional to) its rate of change of momentum. (3)

4.3.2 $F_{\text{net}} = m \cdot a$
 $120 \cos 64^\circ = (16 + 24) \cdot a$
 $52,6 = 40 \cdot a$
 $a = 1,32 \text{ m.s}^{-2}$ (4)



F_N = normal

F_T = tension **OR** F_x = force of bar X on A

F_g = weight or force of gravity

F_N equal in magnitude to F_g

Acceptable symbols (not names) (–1) (4)

4.3.4 **Method 1** (Using block A)

$$F_{\text{net}} = m \cdot a$$

$$F_{\text{TX}} = 16 \times 1,32$$

$$F_{\text{TX}} = \mathbf{21,12 \text{ N}}$$

Method 2 (Using block B)

$$F_{\text{net}} = m \cdot a$$

$$(120 \cos 64^\circ - F_{\text{TX}}) = 24 \times 1,32$$

$$52,6 - 31,68 = F_{\text{TX}}$$

$$F_{\text{TX}} = \mathbf{20,92 \text{ N}} \quad (4)$$

4.3.5 $W = F \Delta x \cos \theta$

$$W = (120 \cos 64^\circ) \times 5$$

$$W = \mathbf{263,02 \text{ J}} \quad (4)$$

4.4 $F_x = 80 \cos 55^\circ = 45,886 \text{ N}$ (right)

$$F_y = 80 \sin 55^\circ = 65,532 \text{ N}$$
 (up)

$$F_g = 15 \times 9,8 = 147 \text{ N}$$
 (down)

$$F_N = 147 - 65,532 = 81,468 \text{ N}$$
 (up)

$$\mu_s = \frac{F_f}{F_N}$$

$$= \frac{45,866}{81,468}$$

$$\mu_s = \mathbf{0,56} \quad (6)$$

[31]

QUESTION 5 MOMENTUM, ENERGY AND POWER

5.1 5.1.1 Method 1

Distance = area under graph

$$= \left(\frac{1}{2} \times 1,4 \times 2\right) + (1 \times 1,4) \\ = 2,8 \text{ m}$$

Method 2

$$\Delta x = \frac{(v_i + v_f) \cdot t}{2}$$

$$\Delta x = \frac{(1+3)}{2} 1,4$$

$$\Delta x = 2,8 \text{ m}$$

Method 3

$$v_f = v_i + at$$

$$3 = 1 + a(1,4)$$

$$a = 1,429 \text{ m.s}^{-2}$$

$$v_f^2 = v_i^2 + 2a\Delta x$$

$$3^2 = 1^2 + 2(1,429)\Delta x$$

$$\Delta x = 2,8 \text{ m}$$

OR

$$\Delta x = v_i \Delta t + \frac{1}{2} a \Delta t^2$$

$$\Delta x = 1 \cdot (1,4) + \frac{1}{2} (1,429)(1,4)^2$$

$$\Delta x = 2,8 \text{ m} \quad (4)$$

$$5.1.2 \quad \Delta p = mv_f - mv_i$$

$$= 21\,000(2-5)$$

$$= -63\,000 \text{ kg.m.s}^{-1}$$

(4)

5.1.3 Method 1

$$F_{\text{net}} = \frac{\Delta p}{\Delta t}$$

$$= -\frac{63\,000}{1,4}$$

(c.o.e. from
5.1.2)

Method 2

$$F_{\text{net}} = \frac{mv_f - mv_i}{\Delta t}$$

$$= \frac{21\,000(2-5)}{1,4}$$

Method 3

$$v_f = v_i + at$$

$$2 = 5 + a(1,4)$$

$$a = -2,143 \text{ m.s}^{-2}$$

$$F_{\text{net}} = m \cdot a$$

$$= 21\,000 \times 2,143$$

$$F_{\text{net}} = 45\,000 \text{ N backwards (in the opposite direction to motion)}$$

(4)

5.1.4 Method 1

$$\Delta p = mv_f - mv_i$$

$$63\,000 = m_Y(3-1) \text{ (c.o.e. from 5.1.2)}$$

$$m_Y = 31\,500 \text{ kg}$$

Method 2

total momentum before collision = total momentum after collision } Method

$$m_X v_{iX} + m_Y v_{iY} = m_X v_{fX} + m_Y v_{fY}$$

$$[(21\,000 \times 5) + (m_Y \times 1)] = [(21\,000 \times 2) + (m_Y \times 3)]$$

$$m_Y = 31\,500 \text{ kg}$$

Method 3

$$v_f = v_i + at$$

$$3 = 1 + a(1,4)$$

$$a = 1,429 \text{ m.s}^{-2}$$

$$F_{\text{net}} = m \cdot a$$

$$45\,000 = m_Y \times 1,429$$

$$m_Y = 31\,490,55 \text{ N}$$

(4)

$$\begin{aligned}
 5.2.1 \quad E_p &= mgh \\
 &= 21\,000 \times 9,8 \times 8 \\
 &= \mathbf{1\,646\,400\,J} \quad (\mathbf{1,65 \times 10^6 J})
 \end{aligned}
 \tag{3}$$

$$\begin{aligned}
 5.2.2 \quad F_{\text{applied}} &= mg \sin \theta + F_{\text{friction}} \quad (\text{method}) \\
 &= 21\,000 \times 9,8 \sin 20^\circ + 21\,000 \quad (\text{conversion}) \\
 &= 70\,387 + 21\,000 \\
 &= \mathbf{91\,387,75\,N}
 \end{aligned}
 \tag{5}$$

$$\begin{aligned}
 5.2.3 \quad P &= F \times v \\
 &= 91\,387,75 \times 1,4 \quad (\text{c.o.e. from 5.2.2}) \\
 &= \mathbf{127\,942,84\,W}
 \end{aligned}
 \tag{4}$$

5.2.4 Some of the force applied by the cable is doing work against friction. (2)

[30]

QUESTION 6 FIELDS

6.1 6.1.1 $g = \frac{GM_{\text{planet}}}{(R_{\text{planet}})^2}$

$$= \frac{6,7 \times 10^{-11} \times 3,3 \times 10^{23}}{(2,44 \times 10^6)^2}$$

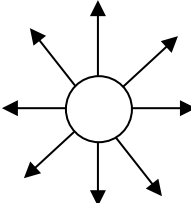
$$= \mathbf{3,71 \text{ m.s}^{-2}} \quad (4)$$

6.1.2 $F_g = m \cdot g$

$$= 250 \times 3,71 \text{ (c.o.e. from 6.1.1)}$$

$$= \mathbf{928,43 \text{ N}} \quad (3)$$

6.2.1



Direction
Shape (not passing through sphere, must touch sphere)

(3)

6.2.2 $E = \frac{kQ}{r^2}$

$$= \frac{9 \times 10^9 \times 6,4 \times 10^{-8}}{(40 \times 10^{-3})^2} \text{ (conversion; } 40 \text{ mm} = 0,04 \text{ m)}$$

$$= \mathbf{360\,000 \text{ N.C}^{-1}} \text{ (} \mathbf{3,6 \times 10^5 \text{ N.C}^{-1}} \text{)} \quad (4)$$

6.2.3 (a) $F = \frac{kq_1q_2}{r^2}$

$$= \frac{9 \times 10^9 \times 6,4 \times 10^{-8} \times 4,8 \times 10^{-8}}{(60 \times 10^{-3})^2}$$

$$\mathbf{F = 7,68 \times 10^{-3} \text{ N}} \quad (4)$$

(b) $F_{\text{balance}} = 9,54 \times 10^{-3} - 7,68 \times 10^{-3}$

$$= \mathbf{1,86 \times 10^{-3} \text{ N}} \quad (2)$$

[20]

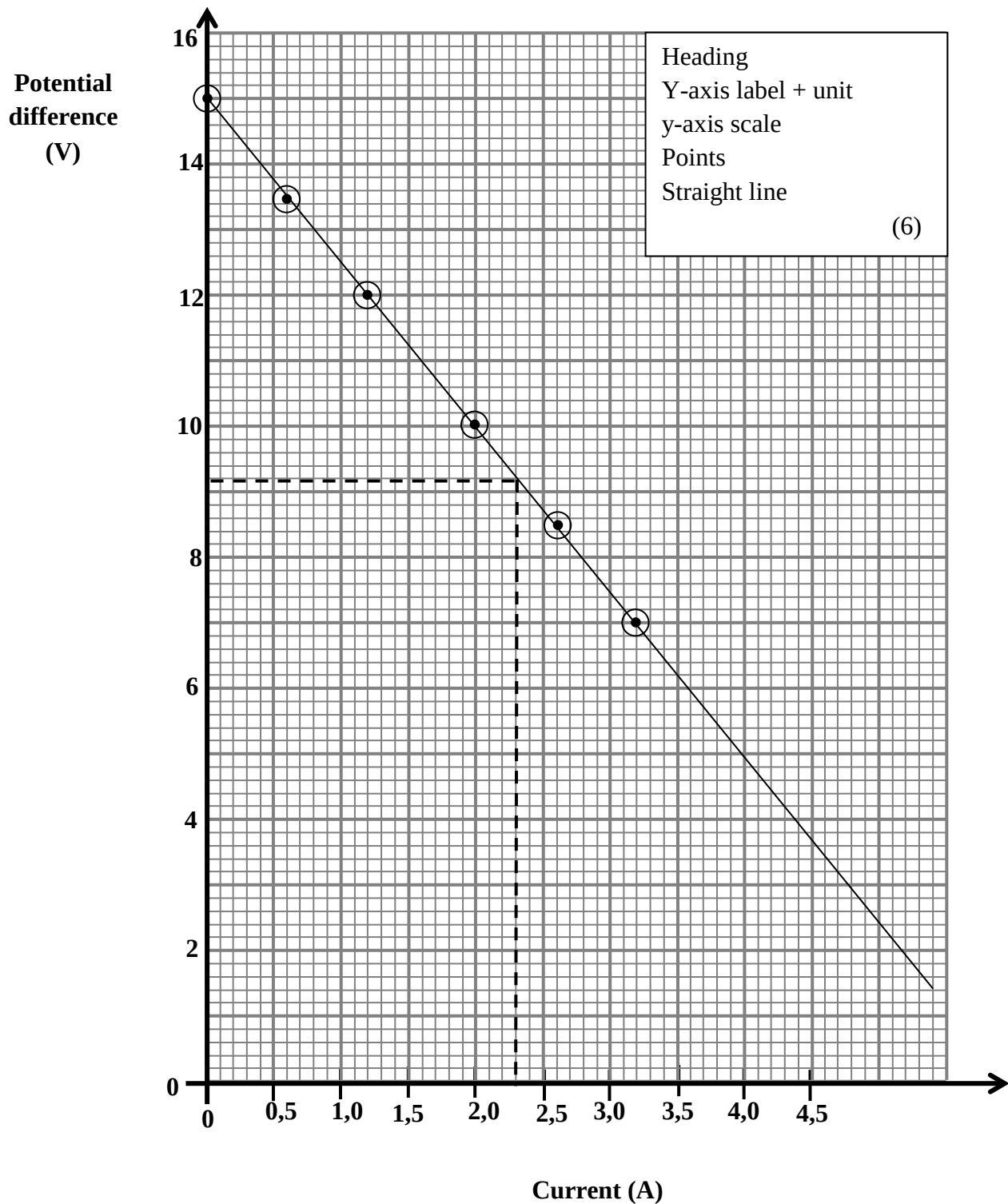
QUESTION 7 ELECTRIC CIRCUITS

7.1 **emf** is the total energy supplied per coulomb of charge by the cell. (2)

7.2 15,0 V (1)

7.3 Potential difference (2)

7.4 Graph to show the relationship between the potential difference across the terminals of a battery and the current through the battery.



7.5 $\pm 9,2 \text{ V}$ (1)

7.6 $r = \text{gradient of graph}$
 $= \frac{15-7}{3,2}$ (Any legitimate calculation of gradient acceptable)
 $r = 2,5 \Omega$

Method 2

$$E = I(R + r)$$

$$E = 15$$

Correct 'pair' for I and R

$$\mathbf{r = 2,5 \Omega}$$

I	R
0,6	22,5
1,2	10
2,0	5
2,6	3,2692
3,2	2,1875

Method 3

$$\text{Lost V} = Ir$$

Correct pair for I and Lost V

$$\mathbf{r = 2,5 \Omega}$$

I	Lost V
0,6	1,5
1,2	3
2,0	5
2,6	6,5
3,2	8

(4)

7.7 More **volts are lost** moving the greater current through the **internal resistance** of the battery.

Lost volts = Ir **OR** p.d. across battery = $\text{emf} - Ir$ Formula = (3)

7.8 Resistance is a material's opposition to the flow of electric current. (2)

7.9 $E = I(R + r)$ **OR** $V = IR$
 $15 = 2(R + 2,5)$ $10 = 2.R$
 $R = 5 \Omega$
 $R_{\text{rheostat}} = (5 - 2)$
 $\mathbf{= 3 \Omega}$

(4)
[25]

QUESTION 8 ELECTRODYNAMICS

8.1 Faraday's law of electromagnetic induction states the emf induced is directly proportional to the rate of change of magnetic flux (flux linkage). (2)

8.2 An alternating current is needed in order to set up a **changing** magnetic field therefore producing a **change in flux** in the secondary coil and hence inducing an emf in the secondary coil. (3)

8.3 The rate of change of magnetic flux linkage in both coils is the same. The induced emf (ϵ) is directly proportional to the number of turns (N)($\epsilon \propto N$); there are **more turns in the secondary coil**.

OR $\frac{\Delta\Phi}{\Delta t}$ is the same for both coils.

$$-\frac{\Delta\Phi}{\Delta t} = \frac{\text{emf}}{N} = \frac{V_p}{N_p} = \frac{V_s}{N_s}$$

Since the **primary coil has less turns** $N_p < N_s$

$$\therefore V_p < V_s \quad (2)$$

8.4 8.4.1 $\frac{N_s}{N_p} = \frac{V_s}{V_p}$

$$N_s = \frac{400\,000}{25\,000} \times 500$$

$$N_s = \mathbf{8\,000 \text{ (turns)}} \quad (3)$$

8.4.2 $V_p I_p = V_s I_s$

$$400\,000 \times I_s = 25\,000 \times 0,5$$

$$I_s = \mathbf{0,03125 \text{ A} \text{ (0,03 A)}}$$

Alternative

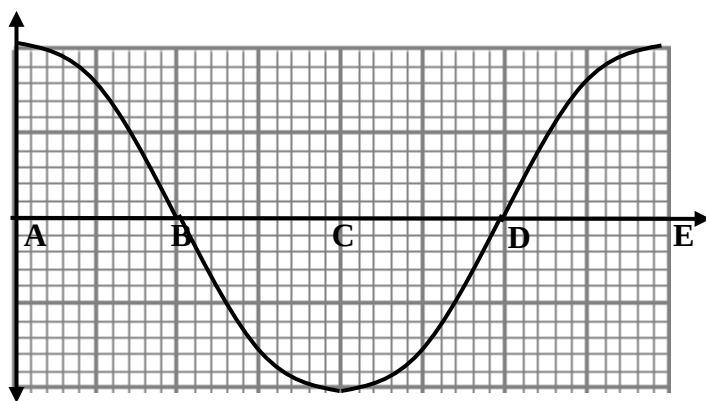
Voltage is stepped up 16 times ($400\,000 / 25\,000$) therefore current is stepped down 16 times

$$I = \frac{0,5}{16} = \mathbf{0,03125 \text{ A}} \quad (3)$$

8.4.3 There will be **less energy (power) lost** in the form of heat in the power lines due to the resistance of the power lines, $P = I^2 R$ ($P \propto I^2$, when R is constant). (3)

8.5

8.5.1
 ε

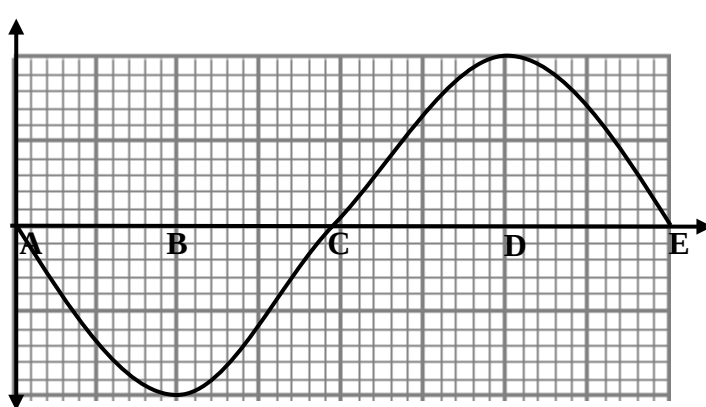


At A $\varepsilon = \text{max}$
At B $\varepsilon = 0$
Alternating current/
(cosine curve)

time (s)

(3)

8.5.2
 ϕ



At A $\phi = 0$
At B $\phi = \text{max}$
Alternating current/
(sine curve)

time (s)

Graphs can be
inverted about the
x-axis.

(3)

[23]

QUESTION 9 PHOTONS AND ELECTRONS

9.1 $E = h.f$

$$\left[-2,4 \times 10^{-19} - (-5,4 \times 10^{-19}) \right] = 6,6 \times 10^{-34} \times f$$

$$\frac{3,0 \times 10^{-19}}{6,6 \times 10^{-34}} = f$$

$f = 4,55 \times 10^{14} \text{ Hz}$ (4)

9.2 (Wavelength A is) **greater** (than wavelength B). (1)

9.3 The lower the energy of the photon released in the transition the longer the wavelength.

Formula: $E = \frac{hc}{\lambda}$ therefore $E \propto \frac{1}{\lambda}$

Less energy is released in transition A than in transition B. (3)

9.4 If $E \propto 1/n^2$ then $E.n^2 = k$ (constant)

n	E	E.n²
1	21,6	21,6
2	5,4	21,6
3	2,4	21,6

Use of TWO energy levels to prove the relationship

Use of THREE energy levels to prove the relationship

(3)
[11]

Total: 200 marks