NATIONAL SENIOR CERTIFICATE EXAMINATION
NOVEMBER 2022

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.

If answer if left as a fraction candidate penalized only ONCE per question (or in each part of a split question).

QUESTION 1

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

QUESTION 2 if incorrect letter included: 0

2.1.1 A, D, G for all (1 mark if only 2 given; 1 mark of ONLY D given)

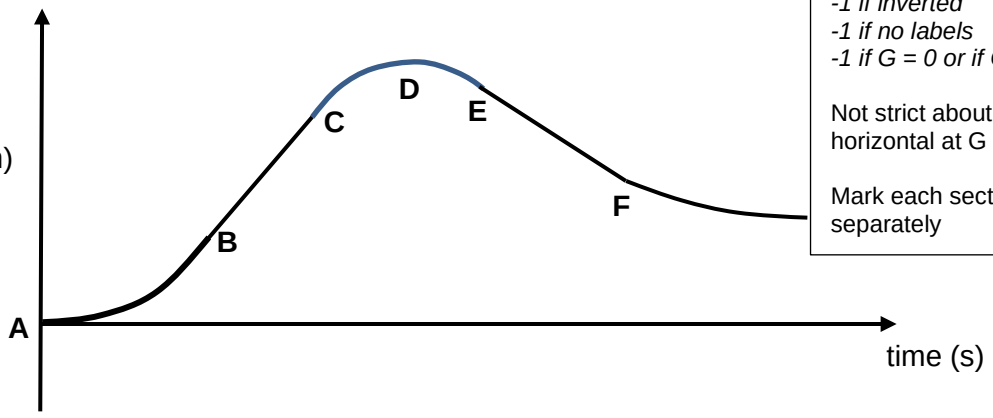
2.1.2 B–C

2.1.3 D–G OR D–E; E–F; F–G

2.1.4 Acceleration is the rate of change of velocity.
Don't accept "over time" but … "per unit time" is acceptable

2.1.5 C–E C–D (only 1); D–E (only 1)

2.1.6



-1 if inverted
-1 if no labels
-1 if G = 0 or if G < 0

Not strict about line horizontal at G

Mark each section separately

2.2 $s_{child} + s_{puppy} = 100$
$2{,}0\,t + 2{,}5\,t = 100$
$t = 22{,}22\ s$

$s_{child} = 2{,}0(22{,}22)$
$s_{child} = 44{,}44$ m

OR

$S_{child} = 2t$

$S_{puppy} = 2{,}5$

$S_{child} + S_{puppy} = 100$
$2t+2{,}5 = 100$
$4{,}5\ t = 100$
$t = 22{,}22$ s

$S_{child} = 2t$
$= 2\ (22{,}22)$
$= 44{,}44$ m

$S_{child} = 2t$

$S_{puppy} = 2{,}5t$

distance = (100 – x)

equating / substituting

+ 44,44 m

$$t_{child} = \frac{s_{child}}{v_{child}}$$
$$= \frac{s_{child}}{2,0}$$
$$t_{puppy} = \frac{s_{puppy}}{v_{puppy}}$$
$$= \frac{(100 - s_{child})}{2,5}$$
$$\frac{s_{child}}{2,0} = \frac{(100 - s_{child})}{2,5}$$
$$2,5\, s_{child} = 2,0(100 - s_{child})$$
$$\boldsymbol{s_{child} = 44,44\ m}$$

2 : 2,5

44,44 : 55,56

= 44,44 m

2,5 + 2 = 4,5 m.s^{-1}

s = ut + ½ at^2

100 = 4,5t + 0

t = 22,22 s

S_{child} = 2t
= 2 (22,22)
= 44,44 m

Approximation method – candidate repeats substitutions to approach the correct answer:
- Evidence must be clear (correct statements are given marks, e.g. Δx = 2t)
- If final answer is correct (44,44 m) then 5 marks
- If method shown and correct but final answer is e.g. 44,5 m, then 4/5 marks given.

QUESTION 3

3.1 $v = u + at$

$0 = u + (-9,8)(0,8)$

$\boldsymbol{u = 7,84\ m{\cdot}s^{-1}}$

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

$0 = u(1,6) + \frac{1}{2}(-9,8)(1,6)^2$

$\boldsymbol{u = 7,84\ m \cdot s^{-1}}$

Could choose down to be positive throughout.

3.2 $s = ut + \frac{1}{2}at^2$

$= (7,84)(0,8) + \frac{1}{2}(-9,8)(0,8)^2$

$\boldsymbol{s = 3,14\ m}$

Carry over initial velocity from 3.1

OR

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

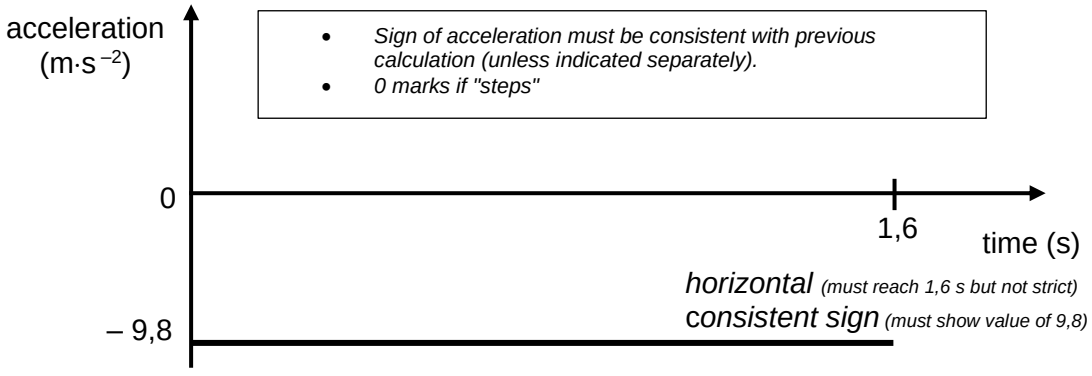
$0^2 = (7,84)^2 + 2(-9,8)s$

$\boldsymbol{s = 3,14\ m}$

Must show "-" of a = +9,8, even though squared

If height left as a negative value, no mark for answers (max 2 marks)

3.3



- *Sign of acceleration must be consistent with previous calculation (unless indicated separately).*
- *0 marks if "steps"*

horizontal (must reach 1,6 s but not strict)
consistent sign (must show value of 9,8)

3.4 $s = ut + \frac{1}{2}at^2$

$s = (5)(1{,}2) + \frac{1}{2}(-9{,}8)(1{,}2)^2$

$s = -1{,}06$ m

$s = 1{,}06$ m

If height left as a negative value, no mark for answer (max 2 marks) EXCEPT if already penalised in 3.2

Max height (1,28 m)

Correct distance

Answer

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

$0^2 = 5^2 + 2(9{,}8)s$

$S = 1{,}28$ m

$V = u + at$

$0 = 5 + (-9{,}8)t$

$t = 0{,}51$ s

$s = ut + ½ at^2$

$= 0 + ½ (-9{,}8)(0{,}69)^2$

$= 2{,}34$ m

Height = 2,34 – 1,28

= 1,06 m

If $s = ½ (u + v)t$ is used with no other calculation, then 0/3 as there are 2 unknown for this equation and it will not produce a height without another calculation.

3.5 $v = u + at$

$v = 5 + (-9{,}8)(1{,}2)$

$v = -6{,}76$ m·s^{-1}

$v = 6{,}76$ m·s^{-1}

Accept a positive or negative answer for 3.5

Don't carry through error of time from 3.4 (0,6 s)

For each option: –1 per error

OR $v = u + at$

$v = 5 + (-9{,}8)(1{,}2)$

$v = -6{,}76$

$= 6{,}76$ m·s^{-1}

OR $s = ½ (u + v) t$

$-1{,}05 = ½ (5 + v) (1{,}2)$

$-0{,}88 = ½ (5 + v)$

$v =$ **6,76 m.s^{-1}**

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

$= 5^2 + 2(-9{,}8)(-1{,}05)$

$= 45{,}58$

v = 6,76 m.s^{-1}

OR $v = u + at$

$= 0 + (-9{,}8)(0{,}69)$

$= -6{,}76$

= **6,76 m.s^{-1}**

OR $s = ½ (u + v) t$

$-2{,}34 = ½ (0 + v) (0{,}69)$

$-3{,}39 = ½ (v)$

$v =$ **6,76 m.s^{-1}**

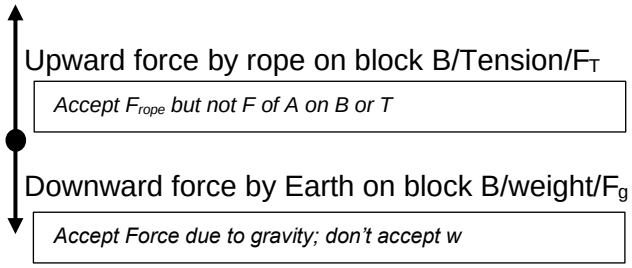
General "rules" for marking 3.5:

- *g and s need to have the same sign*
- *u can be positive or negative if $v^2 = u^2 + 2as$ used*
- *if t = 1,2 s, then u must be opposite sign to g.*
- *if t = 0,18 s, then u must be the same sign as g.*
- *if using v = u + at:*
  - *if t = 0,18 s*
    v = +5 + (+9,8)(0,18)
  - *if t = 0,69 s:*
    v = 0 + (+9,8)(0,69)
    (u must be 0 and s and a must have the same sign)

QUESTION 4

4.1 Weight is the gravitational force the Earth exerts on any object on or near its surface.

4.2



Ignore relative sizes of force arrows

Only symbols from formula sheet accepted unless a key is used.

4.3 When a net force acts on an object, the object accelerates in the direction of the net force. The acceleration is directly proportional to the net force and inversely proportional to the mass of the object.

NOT "indirectly"

Accept "resultant" instead of "net"

Don't accept "it" for acceleration

direction relationship [net force must be mentioned]

OR

The net force acting on an object is equal to the rate of change of momentum.

4.4 $F_{net} = T - F_{g(B)} = m_B a$

OR $F_{NET} = T + F_g = ma$

OR

Accept mass (6) or weight (58, 8) substituted

$F_{net} = T - m_B g = m_B a$

Accept symbols from Q4.2

4.5 $T + 6(-9{,}8) = (6)a$ for block B (anticlockwise is positive)

$-T + 8(9{,}8) = (8)a$ for block A (anticlockwise is positive)

Awarded for 8 kg expression with signage consistency with 6 kg expression taken into account.

$$8(9{,}8) - (8)a + 6(-9{,}8) = 6a$$
$$78{,}4 - 8a - 58{,}8 = 6a$$
$$14a = 19{,}6$$
$$\boldsymbol{a = 1{,}4\ m{\cdot}s^{-2}}$$

Equating mark

If both masses treated as one system: [Max 4/5]

$F_{NET} = ma$
$F_{gA} - F_{gB} = (14)a$ (must use 14 kg)
$A = 1{,}4\ m.s^{-2}$
$F_g + T = ma$ (must use single mass)
$T = 67{,}5\ N$

$T + 6(-9{,}8) = 6(1{,}4)$

$\boldsymbol{T = 67{,}2\ N}$

Substitution mark

Equating and substitution marks are stand alone
Check for the equating of incorrect methods i.e. $F_{NET(A)} = F_{NET(B)}$

4.6 $s = ut + \frac{1}{2}at^2$

$0{,}6 = (0)t + \frac{1}{2}(1{,}4)t^2$

$\boldsymbol{t = 0{,}93\ s}$

Carry over acceleration from 4.5

OR alternative methods

OR $s_A + s_B = 1,2$ (method)
$½ (1,4)t^2 + ½ (1,4)t^2 = 1,2$ (*substitution – a must have same sign*)
$t = 0,93$ s

OR $v^2 = u^2 + 2as$
$= 0^2 + 2(1,4)(0,6)$
$v = 1,3\ m.s^{-1}$

$v = u + at$
$1,3 = 0 + 1,4t$
$t = 0,93$ s

OR BLOCK A:
$F_{NET} = -T + 78,4$
$= -67,2 + 78,4$
$= 11,2$ N

$v^2 = u^2 + 2as$
$= 0^2 + 2(1,4)(0,6)$
$v = 1,3\ m.s^{-1}$

$F_{NET}.\Delta t = m.\Delta v$
$(11,2) . \Delta t = (8)(1,3)$ (substitution)
$t = 0,93$ s

OR BLOCK B:
$F_{NET} = T – 58,8$
$= 67,2 – 58,8$
$= 8,4$ N

$v^2 = u^2 + 2as$
$= 0^2 + 2(1,4)(0,6)$
$v = 1,3\ m.s^{-1}$

$F_{NET}.\Delta t = m.\Delta v$
$(8,4) . \Delta t = (6)(1,3)$ (substitution)
$t = 0,93$ s

OR

If they use energy principles, they only get the mark for 0,6 m being used.

QUESTION 5

5.1 $(p_{total})_{before} = (p_{total})_{after}$

$m_1u_1 + m_2u_2 = m_1v_1 + m_2v_2$

$2(3) + 5(1,5) = 2v_1 + 5(2,5)$

v_i = 0,5 m·s^{-1} right

NB Total or Σ for standalone formula mark

Independent mark

OR $\Delta p_x = -\Delta p_y$ *(not accepting formula if substitution error)*

$m_xv_x - m_xu_x = -(m_yv_y - m_yu_y)$

$2v - 2(3) = -5(2,5 - 1,5)$

5.2 Both experience same force / neither / equal; NLIII
Or explain using principle of conservation of momentum
Rate of change of momentum is equal.

5.3 Neither / experience same change in momentum NL2
Principle of conservation of momentum (equal change in momenum); equal impulse.
If proved by calculation, they must draw a conclusion from values – i.e. mention a change in momentum
Not accepting equal rate of change of momentum

5.4 The product of the net force and the time for which it acts.
resultant the contact time

NOT just time

5.5 $F_{net} = \frac{\Delta p}{\Delta t}$

$F_{net} = \frac{(5)(0) - 5(2,5)}{0,2}$

$F_{net} = -62,5$

F_{net} = 62,5 N

Accept a negative answer

OR $v = u + at$
$= 2,5 + a(0,2)$
$a = -12,5$
formula for both
$F_{NET} = ma$
$= 5(-12,5)$ (3 values)
$= -62,5$
$= 62,5$ N

OR $v = u + at$
$0 = 2,5 + a(0,2)$
$a = -12,5$
formula for both
$V^2 = U^2 + 2as$
$0 = (2,5)^2 + 2(-12,5)s$
$S = 0,25$ m

$W_{net} = \Delta Ek$
$F_{NET}(0,25) = -½(5)(2,5)^2$

$F_{NET} = -62,5$
$= 62,5$ N

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

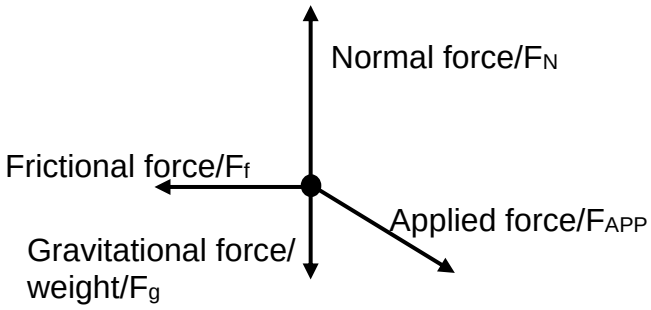
Not marking sign

$= \frac{-5(2,5)}{0,2}$

$= 62,5$ N

QUESTION 6

6.1



Accept components instead of applied force OR accept if components given in addition to applied force, as long as they are dashed lines.

6.2 $F_{vert} = F.\sin\theta$

$F_{vert} = 25.\sin 15$

$\boldsymbol{F_{vert} = 6{,}47\ N}$

$F_{vert} = F.\cos\theta$

$F_{vert} = 25.\cos 75$

$\boldsymbol{F_{vert} = 6{,}47\ N}$

NB not just "force" perpendicular to surface

6.3 The perpendicular force exerted **by** a surface on an object in contact with it.

Independent mark

6.4 $F_N = F_g + F_{app,vert}$ *(as scalars)*

$F_N = (0{,}01)(9{,}8) + 6{,}47$

$\boldsymbol{F_N = 6{,}57\ N}$

Carry over F_{vert} from 6.2

Watch out because 6,47 – 0,098 = 6,37 N

6.5 $F_{fk} = \mu F_N$

$F_{fk} = (0{,}6)(6{,}57)$

$\boldsymbol{F_{fk} = 3{,}94\ N}$

Carry over F_N from 6.5

Independent mark

6.6 $F_{net} = F_{app,hor} - F_{fk}$ *(as scalars)*

$F_{net} = 25\cos 15° + (-3{,}94)$

$\boldsymbol{F_{net} = 20{,}21\ N}$

Formula must be correct to get this mark

Carry over F_{fk} from 6.5

Don't accept "net work done"…

6.7 The work done by a net force [on an object] is equal to the change in the kinetic energy of the object.

Object only needs to be mentioned once

6.8 $F_{net} \cdot s = \Delta E_K$

$20{,}21(0{,}2) = \Delta E_K$

$\boldsymbol{\Delta E_K = 4{,}04\ J}$

$F.s = \Delta E_k$ only allocated a formula mark if $F_{NE}T$ substituted

Carry over F_{net} from 6.6

$W_{NET} = W_{HOR} + W_f$
$(20,21)(0,2) = 25.\cos 15(0,2) + W_f$
$W_f = 0,79\ J$

6.9 $\Delta E_{th} = F_f \cdot s$

$\Delta E_{th} = 3{,}94(0{,}2)$

$\boldsymbol{\Delta E_{th} = 0{,}79\ J}$

W = F.s only allocated a formula mark if F_f substituted

Carry over F_{fk} from 6.5

$W_{NET} = W_{HOR} + W_f$
$(20,21)(0,2) = 25.\cos 15(0,2) + W_f$
$W_f = 0,79\ J$

QUESTION 7

particle / mass / object

Must say that this is an attractive force

7.1 7.1.1 Every particle with mass in the universe attracts every other particle with a force that is directly proportional to the product of their masses and inversely proportional to the square of the distance between their centres.

them

7.1.2 $F = \frac{GM_1M_2}{r^2}$

Check that they haven't substituted 6,4 here

$3,6 = \frac{(6,7\times10^{-11})(360)(6,0\times10^{24})}{r^2}$

$r^2 = \frac{(6,7\times10^{-11})(360)(6,0\times10^{24})}{3,6}$

$r = 200\times10^8$ m

OR

$F = \frac{GM_1M_2}{r^2}$

$3,6 = \frac{(6,7\times10^{-11})(360)(6,0\times10^{24})(\text{sub})}{(r+6,4x10^6)^2}$

$(r = 6,4x10^6)^2 = \frac{(6,7\times10^{-11})(360)(6,0\times10^{24})}{3,6}$

$r = 2,00\times10^8 - 6,4x10^8$ m

$r = 1,94\times10^8$ m

height above surface $= 2,00 \times 10^8$ m $- 6,4 \times 10^6$

$=$ **$1,94 \times 10^8$ m** OR 194×10^6 m OR 194×10^3 km

Check working because 1,94 rounds to 2,00 – if method correct, this is acceptable!

7.1.3 $g = \frac{F}{m}$

$g = \frac{3,6}{360}$

***g* = 0,01 m·s^{-2}** OR N · kg^{-1}

OR

$g = G\frac{M}{r^2}$

$g = (6,67\times10^{-11})\frac{6,0\times10^{24}}{(200\times10^6)^2}$

***g* = 0,01 m·s^{-2}** OR N · kg^{-1}

7.2 7.2.1 Z

7.2.2 Y

Be careful of X vs Y!

7.2.3 $F = \frac{kq_1q_2}{r^2}$

Check that not E =
If all else correct, MAX 3/4

$F = \frac{(9\times10^9)(2\times10^{-6})(6\times10^{-6})}{(5\times10^{-2})^2}$ *(numerator)* *(denominator)*

***F* = 43,2 N**

7.2.4 $charge\ per\ sphere = \frac{total\ system\ charge}{2}$

$$= \frac{(+6\times10^{-6} + +2\times10^{-6})}{2}$$

$$= \mathbf{4 \times 10^{-6}\ C}\ \text{OR}\ 4\ \mu\text{C}$$

7.2.5 $electrons\ transferred = \frac{change\ in\ charge}{charge\ per\ electron}$

$$= \frac{2\times10^{-6}}{1{,}6\times10^{-19}}$$

$$= 1{,}25\times10^{13}\ \text{electrons}$$

Ignore – if given

7.2.6 from A to B

QUESTION 8

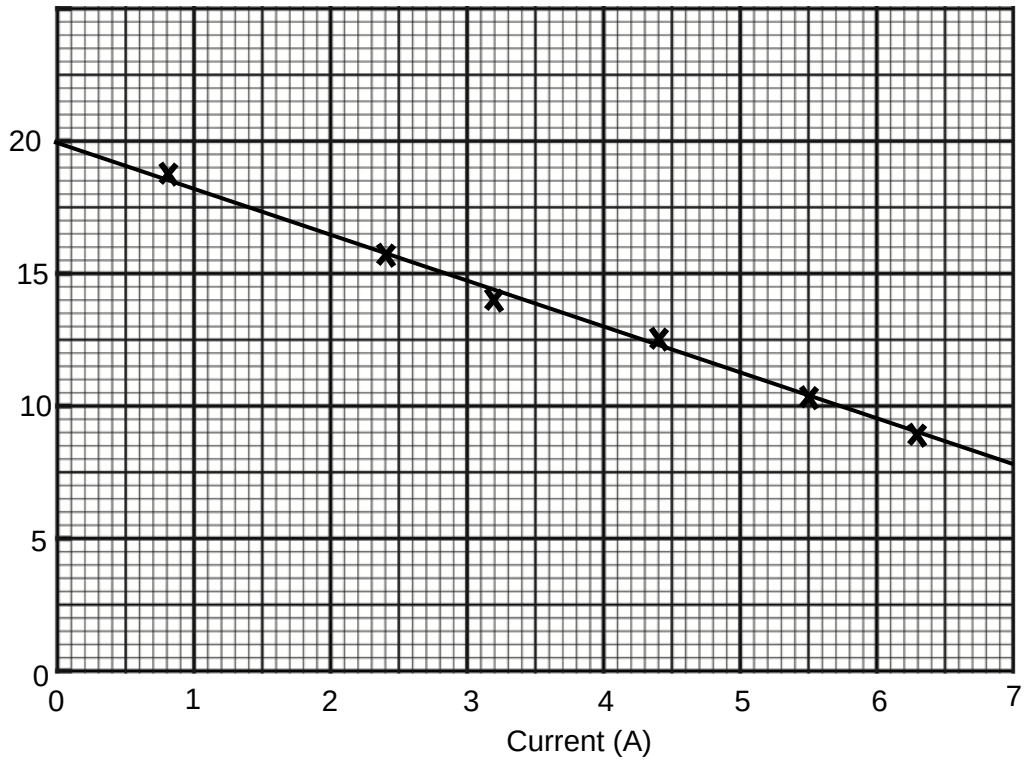
8.1 8.1.1 Heading
y-axis title and unit
y-axis scale (plotted points > $\frac{1}{2}$ graph paper)
plotted points
line of best fit (line must extend beyond plotted points)

Non-linear scale MAX 2/6

Awful scale -1

Incorrectly labelled scale or inconsistent (e.g. 0 in wrong place)

Graph showing the reading on the voltmeter vs the current through the circuit.



8.1.2 $gradient = \frac{\Delta y}{\Delta x}$

$gradient = \frac{values\ from\ y\text{-}axis}{values\ from\ x\text{-}axis}$

-1 if points not shown

If points from table but not on LOBF:
Formula
Unit
X even if in range
If on LOBF – full marks

(values must be from LOBF on graph – not data points)
$gradient = -1{,}75\ \Omega$ (accept 1,6 to 1,9)
[unit must be given Ω *or* $V \cdot A^{-1}$*]*

8.1.3 $V_{load} = emf - Ir$
OR $V_{term} = -rI + emf$
$gradient = -r$
$r = 1{,}75\ \Omega$

Equation must include V_{LOAD} *or* V_{TERM} *and Ir*

Max 1/3 if -1,75 Ω only
Max 2/3 if formula included

If no

8.1.4 **20 V** (*y*-intercept)

[carry over whatever]

They didn't have to cut the y axis – they could have used a ruler to get value.

8.1.5 $emf = (R + r)$

$20 = 4(R + 1{,}75)$

$\boldsymbol{R = 3{,}25\ \Omega}$

Carry over emf and r from 8.1.3 and 8.1.4 respectively

If 8.1.3 not answered, c.o. from 8.1.2

OR Read off $V = 13$ V

[carry over from their LOBF]

If scale non-linear: MAX 2/3 (miss 1st mark)

$V = IR$

$13 = (4)R$

If value matches graph – method mark can be given

$\boldsymbol{R = 3{,}25\ \Omega}$

8.2 8.2.1 $P = \dfrac{V^2}{R}$

$60 = \dfrac{12^2}{R}$

$\boldsymbol{R = 2{,}4\ \Omega}$

Watch out for v is proportional to I … get 0

Accept "voltage", But not "emf"

8.2.2 Current through a conductor is directly proportional to the potential difference across the conductor at constant temperature.

Provided resistance stays constant

8.2.3 $R_{TOTAL} = \dfrac{V}{I} = \dfrac{12}{6} = 2\ \Omega$

If they stop here, no carry over to 8.2.4

$\dfrac{1}{R_P} = \dfrac{1}{R_1} + \dfrac{1}{R_2}$

Independent method mark

$\dfrac{1}{2} = \dfrac{1}{R} + \dfrac{1}{2{,}4}$

$\boldsymbol{R = 12\ \Omega}$

Carry over R from 8.2

OR

$I_{bulb} = \dfrac{V_{bulb}}{R_{bulb}} = \dfrac{12}{2{,}4} = 5\ A$ **OR** $I_{bulb} = \dfrac{P}{V_{bulb}} = \dfrac{60}{12} = 5\ \text{A}$

$\therefore I_R = 6\ A - 5\ A = 1\ A$

$R = \dfrac{V_R}{I_R} = \dfrac{12}{1}$

$\boldsymbol{R = 12\ \Omega}$

8.2.4 $W = \dfrac{V^2 t}{R} = \dfrac{12^2}{12}\ (2 \times 60) = \mathbf{1\ 440\ J}$

OR

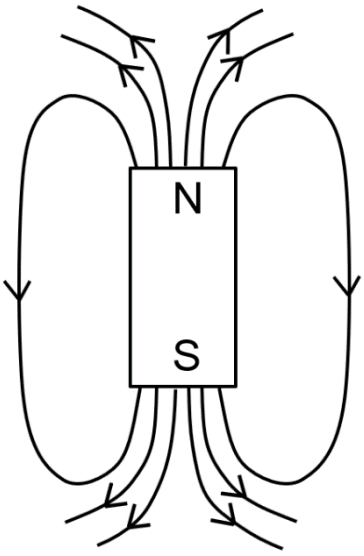
$W = VIt = (12)(1)\ (2 \times 60) = \mathbf{1\ 440\ J}$

OR

$W = I^2Rt = 1^2(12)\ (2 \times 60) = \mathbf{1\ 440\ J}$

QUESTION 9

9.1 9.1.1



direction of arrows
shape of field
symmetry

(3)

9.1.2 The induced current flows in a direction so as to set up a magnetic field to oppose the change in magnetic field.

flux

2 or 0

9.1.3 clockwise

9.1.4 Falling magnet causes strength of magnetic field in coil to (increase)/change. Coil experiences a change in flux.
Change in flux induces an emf/electric current in the metal ring.

9.1.5 moving the magnet faster

OR	Throwing the magnet
OR	Decreasing the temperature of the ring to reduce R

OR

dropping the magnet from a greater height

9.1.6 The product of the number of turns on the coil and the flux through the coil.

9.1.7 The induced current would be much greater as a coil has more turns/loops.

greater flux linkage

9.2 9.2.1 into the page

9.2.2
- Move the loop into the magnetic field **OR** move the loop out of the magnetic field
- With the loop in the field, change the shape of the wire loop
- With the loop in the field, rotate the loop.

Any 2

QUESTION 10

10.1 The **photons** from the UV radiation have **enough** energy to eject electrons.

10.2 The minimum amount of energy needed to emit an electron from the surface of a metal.

eject / knock out

2 or 0

10.3 $4,3 \times 1,6 \times 10^{-19}$

$= \mathbf{6,88 \times 10^{-19}\ J}$

10.4 $$hf = W_0 + E_{K(\max)}$$

$$\left(6,6 \times 10^{-34}\right)\left(15 \times 10^{14}\right) = 6,88 \times 10^{-19} + E_{K(\max)}$$

Carry over W_o from 10.3

$$\boldsymbol{E_{K(\max)} = 3,02 \times 10^{-19}\ J}$$

10.5 $$E_{K(\max)} = \frac{1}{2}mv^2$$

$$3,02 \times 10^{-19} = \frac{1}{2}\left(9,1 \times 10^{-31}\right)v^2$$

Carry over $E_{k(max)}$ from 10.4

$$\boldsymbol{v = 8,15 \times 10^5\ m \cdot s^{-1}}$$

10.6 When the electrons are ejected from the zinc disc, the electroscope becomes increasingly positive and the positively charged leaves repel one another.

Total: 200 marks