NATIONAL SENIOR CERTIFICATE EXAMINATION
MAY 2024

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

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

QUESTION 2

2.1 2.1.1 Acceleration is *the rate of change of velocity.*

2.1.2 $s = \text{area under curve}$

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

OR $(2)(0,4) + \frac{1}{2}(0,4 + 1,0)(4)$

$\mathbf{s = 3,6\ m}$

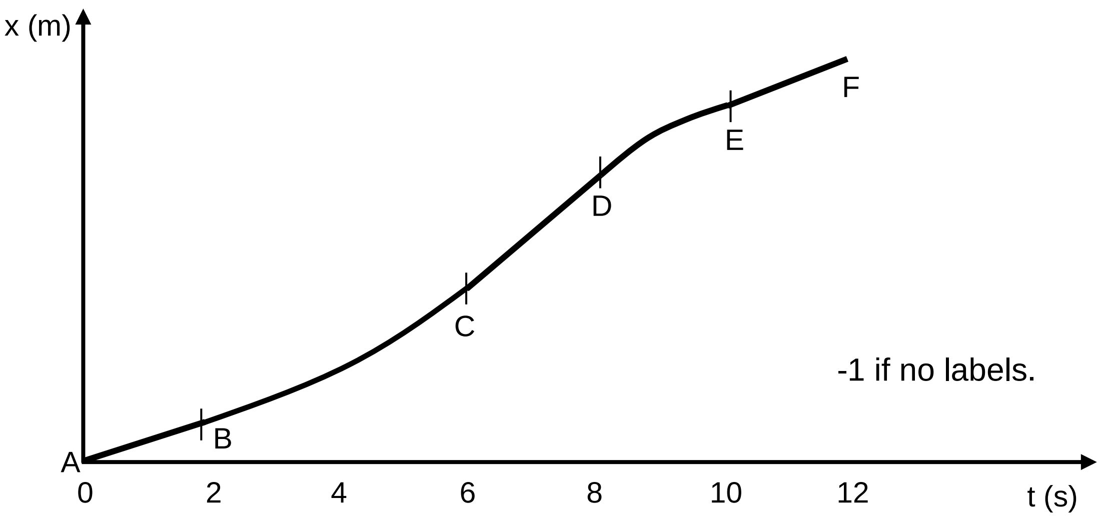
2.1.3 $a = \frac{v - u}{t}$ or gradient of $v - t$ graph

$a = \frac{1,0 - 0,4}{4}$

$\mathbf{a = 0,15\ m \cdot s^{-2}}$

2.1.4 8–10 seconds OR D–E

2.1.5



-1 if no labels.

2.2 2.2.1 Speed is *the rate of change of distance.*

2.2.2 $\text{speed} = \dfrac{\text{distance}}{\text{time}}$

$$v = \frac{400}{t} \qquad \frac{v}{2} = \frac{400}{360 - t}$$

$$vt = \frac{v(360 - t)}{2}$$
$$2t = 360 - t$$

$$t = 120\,s$$
$$v = \frac{400}{120}$$
$$\mathbf{v = 3{,}33\ m \cdot s^{-1}}$$

OR $t_1 + t_2 = 6(60)$

$$\frac{400}{v} + \frac{400}{v/2} = 360$$
$$400 + 800 = 360v$$
$$\mathbf{v = 3{,}33\ m \cdot s^{-1}}$$

QUESTION 3

3.1 Displacement is *a change of position.*

3.2

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

$$10 = (0)(3) + \frac{1}{2}(a)(3)^2$$

$$\mathbf{a = 2{,}22\ m \cdot s^{-2}}$$

3.3

$$s = \left(\frac{u+v}{2}\right)t$$

$$10 = \left(\frac{0+v}{2}\right)(3)$$

$$\mathbf{v = 6{,}67\ m \cdot s^{-1}}$$

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

$$v^2 = (0)^2 + 2(2{,}22)(10)$$

$$\mathbf{v = 6{,}67\ m \cdot s^{-1}}$$

OR $v = u + at$

$$v = 0 + (2{,}22)(3)$$

$$\mathbf{v = 6{,}67\ m \cdot s^{-1}}$$

3.4

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

$$0^2 = (6{,}67)^2 + 2(-9{,}8)(s)$$

$$s = 2{,}27\ m$$

Could choose down to be positive throughout.

Total height $= 10 + 2{,}27$ (method)

Total height $= 12{,}27$ m

3.5

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

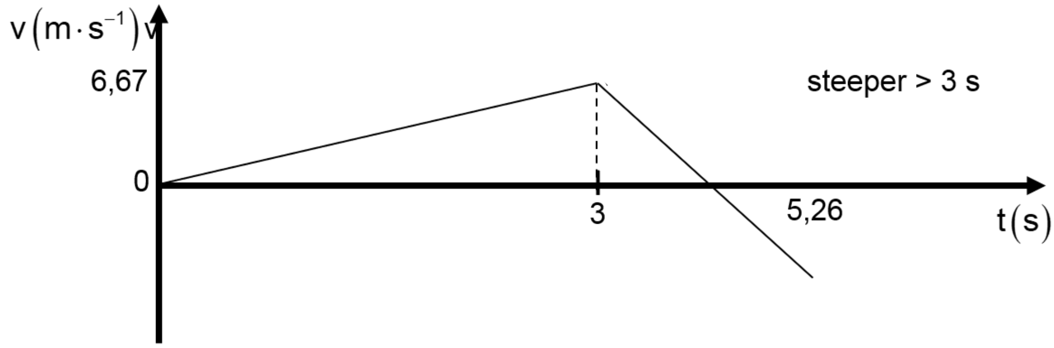
$$-10 = (6{,}67)t + \frac{1}{2}(-9{,}8)(t)^2$$

$$t = 2{,}26s$$

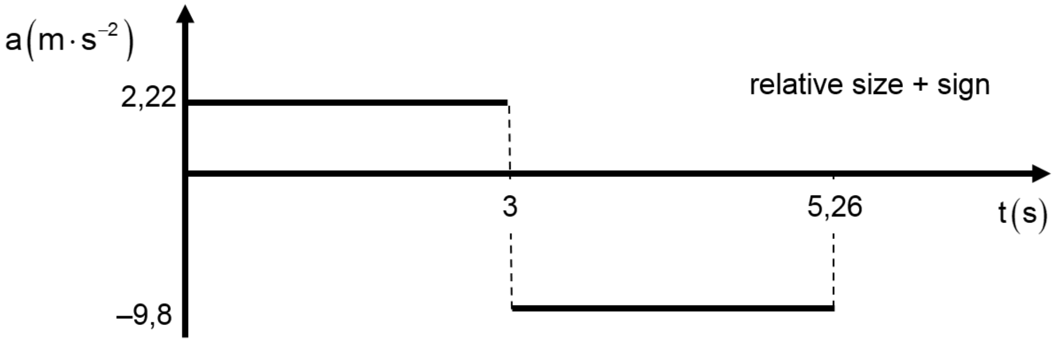
Total time $= 2{,}26 + 3$ (method)

Total time $= 5{,}26$ s

3.6


v(m·s⁻¹)✓
6,67
0
3
5,26
t(s)
steeper > 3 s

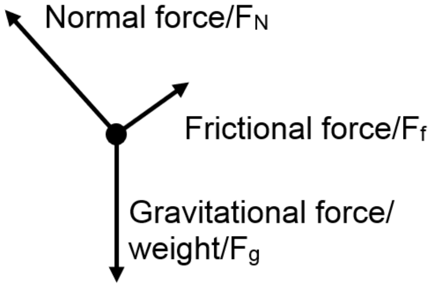
3.7


a(m·s⁻²)
2,22
3
5,26
t(s)
–9,8
relative size + sign

QUESTION 4

4.1 4.1.1 The frictional force is *the force that opposes the motion of an object.*

4.1.2



4.1.3 $F_{\text{g,perpendicular}} = mg.\cos\theta$

$F_{\text{g,perpendicular}} = (7)(9,8).\cos 36$

$\mathbf{F_{g,perpendicular} = 55,50\ N}$

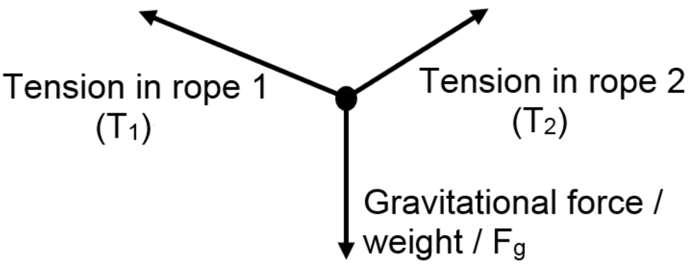
4.1.4 $F_{fs}^{max} = \mu_s F_N$

$(7)(9,8).\sin 36 \checkmark = \mu(55,50)$

$\boldsymbol{\mu = 0,73}$

4.1.5 EQUALLY LIKELY
independent of mass OR at F_{fs}^{max} mass cancels OR μ is constant OR can answer by calculation

4.2 4.2.1



4.2.2 $T_{HOR} = T_1.\cos 35$

4.2.3 $T_1.\cos 35° = T_2.\cos 65°$

So, $\mathbf{T_1 = \dfrac{T_2.\cos 65°}{\cos 35°}}$

$F_g = T_1.\sin 35° + T_2.\sin 65°$

$$(0,6)(9,8) = \frac{(T_2.\cos 65°).\sin 35°}{\cos 35°} + T_2.\sin 65°$$

$\mathbf{T_2 = 4,89\ N}$

$\mathbf{T_1 = 2,52\ N}$

QUESTION 5

5.1 5.1.1 In the absence of air resistance or any external forces, the mechanical energy of an object is constant.

5.1.2 $E_K = \frac{1}{2}mv^2 = \frac{1}{2}(m)(3)^2 = \mathbf{4{,}5\ \mathit{m}}$

5.1.3
$$(E_P + E_K)_{0\,m} = (E_P + E_K)_{0,4\,m}$$
$$\left(0 + \frac{1}{2}mv^2\right)_{0\,m} = \left(mgh + \frac{1}{2}mv^2\right)_{0,4\,m}$$
$$\left(0 + \frac{1}{2}m(3)^2\right)_{0\,m} = \left(m(9,8)(0,4) + \frac{1}{2}mv^2\right)_{0,4\,m}$$
$$4,5\,m = 3,92 + \frac{1}{2}mv^2$$
$$\mathbf{v = 1{,}08\ m \cdot s^{-1}}$$

5.1.4 $E_K - W_{th} = E_P$
4,5m – 0,8 = m(9,8)(0,24)
m = 0,37 kg

5.2 5.2.1 The product of the displacement and the component of the force parallel to the displacement.

5.2.2 $F = F_g = (40)(9,8) = 392$ N
W = F.s
W = 392(2,5)
W = 980 J

OR W = mgh
W = (40)(9,8)(2,5)
W = 980 J

5.2.3 $P = \frac{W}{t}$
$P = \frac{980}{4}$ *(c.o.e. from 5.2.2)*
P* = 245 *W

5.2.4 Same work. Same mass lifted through same height.

QUESTION 6

6.1 6.1.1 *Two-point charges in free space or air exert forces on each other. The force is directly proportional to the product of the charges and inversely proportional to the square of the distance between the charges.*

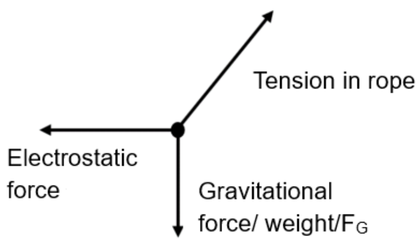
6.1.2

$$F = \frac{kQ_1Q_2}{r^2}$$

$$F = \frac{(9\times10^{9})(20\times10^{-12})(10\times10^{-12})}{(15\times10^{-3})^2}$$

$$\boldsymbol{F = 8\times10^{-9}\,N}$$

6.1.3



6.1.4 Same tension (neither string) as in equilibrium and the weight of each sphere is the same and the electrostatic force on each sphere is the same.

6.2 6.2.1 Gravitational field is *the force acting per unit mass.*

6.2.2

$$g = \frac{GM_{Earth}}{r^2}$$

$$g = \frac{(6,7\times10^{-11})(6\times10^{24})}{(36\times10^{9} + 6,4\times10^{6})^2\ \text{(conversion)}}$$

$$\mathbf{g = 0,22\ N\cdot kg^{-1}}\ \text{ or }\ \mathbf{m\cdot s^{-2}}$$

6.2.3

$$F = m_{Satellite}\,g$$

$$F = (0,22)(6\ 200)$$

(*c.o.e from 6.2.2*) at the end of 2nd line

$$\mathbf{F = 1\,386\ N}$$

OR

$$F = \frac{GM_{Earth}M_{Satellite}}{r^2}$$

$$F = \frac{(6,7\times10^{-11})(6\times10^{24})(6\ 200)}{(36\times10^{6} + 6,4\times10^{6})^2}$$

$$\mathbf{F = 1\,386\ N}$$

QUESTION 7

7.1 7.1.1 12 V

7.1.2 Current is *the rate of flow of charge.*

7.1.3 $V_{18\Omega} = I_{18\Omega}.R_{18\Omega}$

$$I_{18\Omega} = \frac{V_{18\Omega}}{R_{18\Omega}}$$

$$I_{18\Omega} = \frac{6}{18}$$

$$\mathbf{I_{18\Omega} = 0,33\ A}$$

7.1.4 $\frac{1}{R_P} = \frac{1}{R_1} + \frac{1}{R_2}$

$$\frac{1}{R_P} = \frac{1}{14} + \frac{1}{12}$$

$$\mathbf{R_P = 6,46\ \Omega}$$

7.1.5 $\text{emf} = I(R + r)$

$$12 = 0,33(18 + 6,46 + r)$$

$$\mathbf{r = 11,90\ \Omega}$$

7.1.6 $P = I^2R$

$$P = 0,33^2(11,9)$$

$$\mathbf{P = 1,30\ W}$$

7.1.7 $V_{12\Omega} = I_{12\Omega}.R_{12\Omega}$

$$= 0,33 \times 6,46$$

$$= 2,13\ V$$

$$V_{12\Omega} = I_{12\Omega}.R_{12\Omega}$$

$$2,13 = I_{12\Omega}.12$$

$$\mathbf{I_{12\Omega} = 0,18\ A}$$

OR $V_{12\Omega} = I_{12\Omega}.R_{12\Omega}$

$$I_{12\Omega} = \frac{V_{12\Omega}}{R_{12\Omega}}$$

$$I_{12\Omega} = \frac{12 - 18 \times 0,33 - 11,90 \times 0,33}{12}$$

$$\mathbf{I_{12\Omega} = 0,18\ A}$$

7.1.8 $I_{14\Omega} = 0{,}33 - 0{,}18 = 0{,}15\text{A}$

$W = I^2Rt$

$W = 0{,}15^2(14)(3 \times 60)$

$\mathbf{W = 56{,}7\ J}$

7.2 $\text{Cost} = \text{power} \times \text{time} \times \text{cost / unit}$

$\text{Cost} = 3\text{ kW} \times 0{,}75\text{ h} \times \text{R}2{,}60$

$\mathbf{Cost = R5{,}85}$

QUESTION 8

8.1 8.1.1 *The induced current flows in a direction so as to set up a magnetic field to oppose the change in magnetic flux.*

8.1.2 anticlockwise

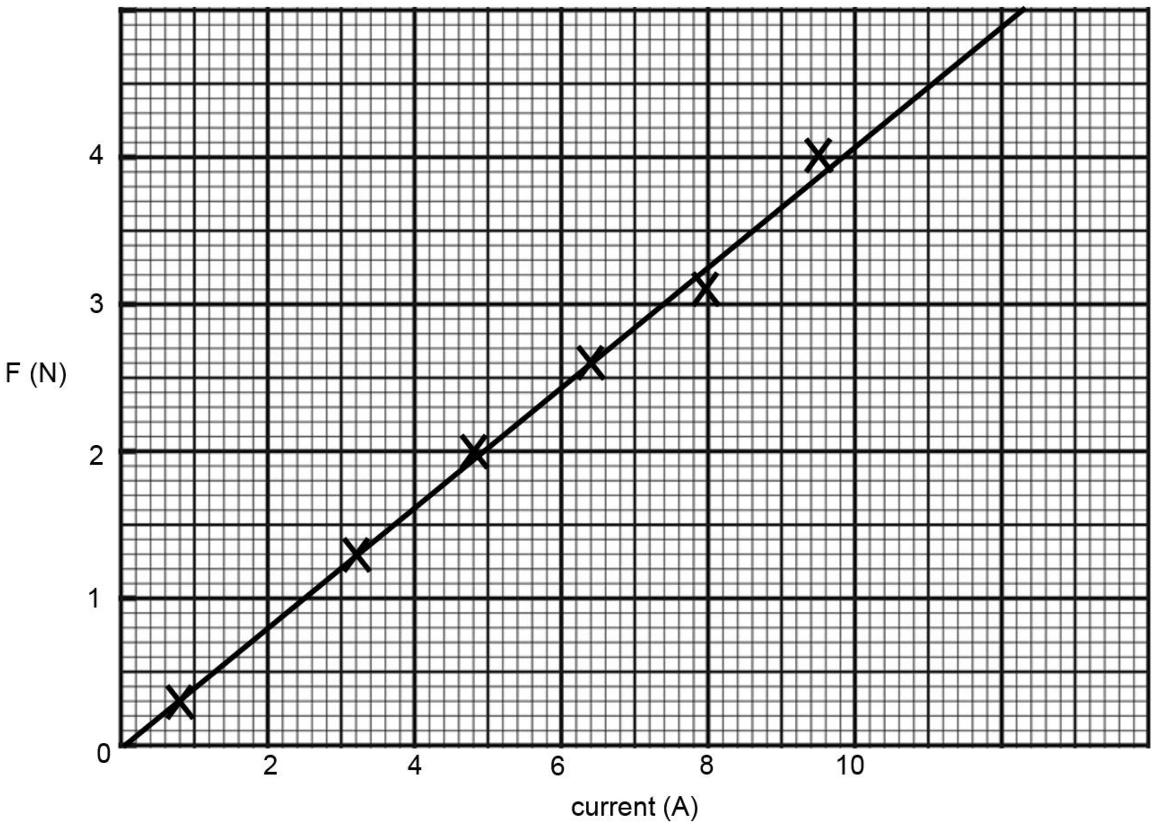
8.1.3 move the loop faster or increase magnetic field strength

8.2 8.2.1 upwards

8.2.2 The reading would increase.
Force on magnet is down (NLIII) and force increases as current increases.

8.2.3 Heading
Both axes labelled
Unit included in labels on both axes
scale (plotted points $> \frac{1}{2}$ graph paper)

plotted points
line of best fit (to origin & extended beyond last point)



8.2.4 $\text{gradient} = \frac{\Delta y}{\Delta x}$

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

(values must be from LOBF on graph – not data points)

$\textbf{gradient} = \mathbf{0,41}$ (accept 0,37 to 0,45)

$\left(\textbf{N.A.}^{-1} - \textbf{units not required}\right)$

8.2.5 F = IℓB

ℓ = 1 so F = BI

Gradient = B

B = 0,41 T

QUESTION 9

9.1 Threshold (cut-off) frequency (f_0) is *the minimum frequency of incident radiation at which electrons will be emitted from a particular metal.*

9.2 $8,6 \times 10^{14}$ Hz

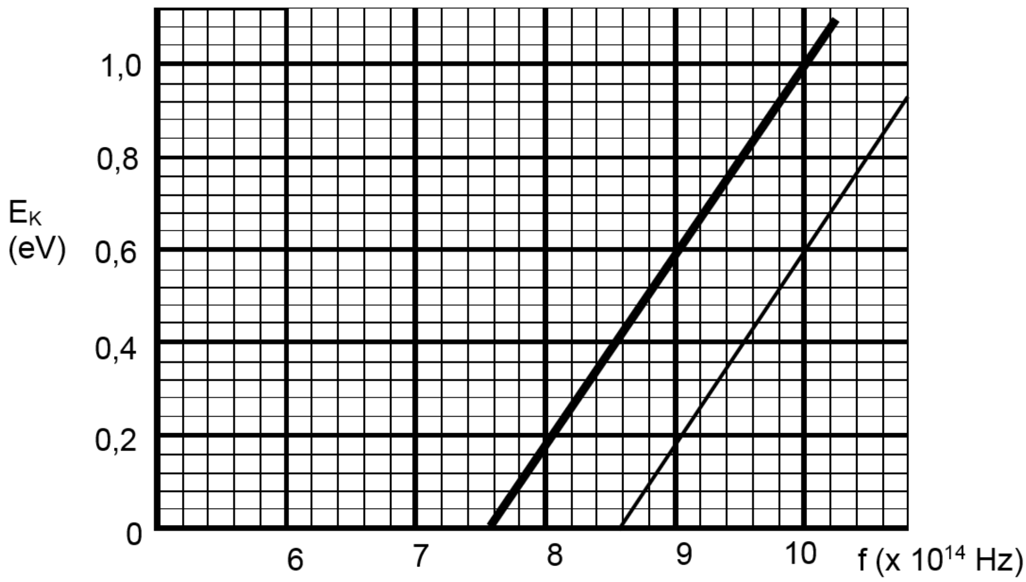
9.3 $E = hf = 8,6 \times 10^{14} \times 6,6 \times 10^{-34}$

$E = 5,68 \times 10^{-19}$ J

$E = \frac{5,68 \times 10^{-19}}{1,6 \times 10^{-19}} = \mathbf{3,55\ eV}$

Uranium

9.4



parallel to original line (same gradient)
smaller threshold frequency (*x*-intercept)

9.5 9.5.1 No effect
Intensity does not affect the energy of the photons OR same frequency.

9.5.2 Greater rate of emission
More photons striking metal per second (greater number of photons).

Total: 200 marks