NATIONAL SENIOR CERTIFICATE EXAMINATION
NOVEMBER 2023

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.

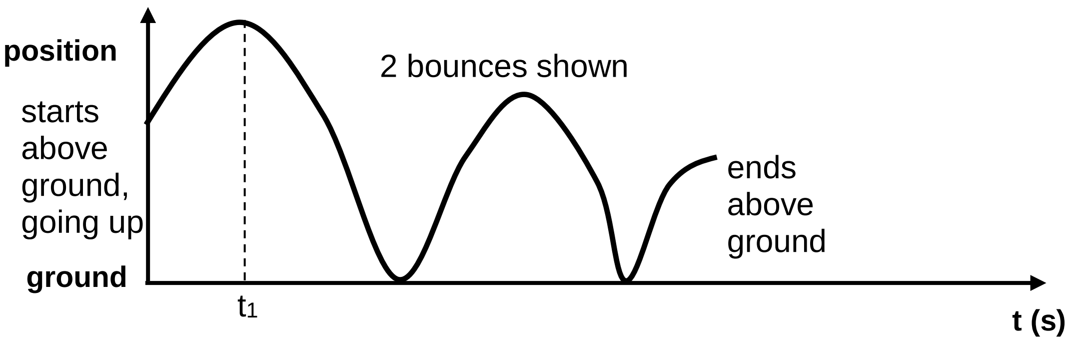
QUESTION 1

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

QUESTION 2

2.1 Gradient of a velocity–time graph is acceleration.
The acceleration of the ball is constant / the ball is in free fall.

2.2



2.3 t_1 correctly labelled

2.4 $v = u + at$ OR gradient : gradient = $9{,}8 = \frac{0 - 2{,}8}{t_1}$

$0 = 2{,}8 + (-9{,}8)(t_1)$

$\boldsymbol{t_1 = 0{,}29}$ **s** $\boldsymbol{t_1 = 0{,}29}$ **s**

2.5 $v_1^2 = u^2 + 2as$

$v_1^2 = (2{,}8)^2 + 2(-9{,}8)(-0{,}9)$

$v_1^2 = 25{,}48$

$\boldsymbol{v_1 = 5{,}05}$ **m·s^{-1} downwards**

2.6 $v = u + at$

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

$\boldsymbol{t = 0{,}80\ \mathrm{s}}$

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

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

$\boldsymbol{t = 0{,}80\ \mathrm{s}}$

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

$-0{,}9 = \left(\frac{2{,}8 + (-5{,}05)}{2}\right)t$

$\boldsymbol{t = 0{,}80\ \mathrm{s}}$

QUESTION 3

3.1 time taken / time interval

3.2 2,9 [no unit required as in a table, but addition of unit not penalised]

3.3 Heading
x-axis *and y*-axis labels
x-axis *and y*-axis units
appropriate scales (plotted points > $\frac{1}{2}$ graph paper)

plotted points
line of best fit

3.4 $gradient = \frac{\Delta y}{\Delta x}$

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

(values must be from LOBF on graph – not data points)
gradient = 0,4 m·s^{-2} (accept 0,35 to 0,45)

3.5 $s = ut + \frac{1}{2}at^2$

$u = 0$ m·s^{-1}

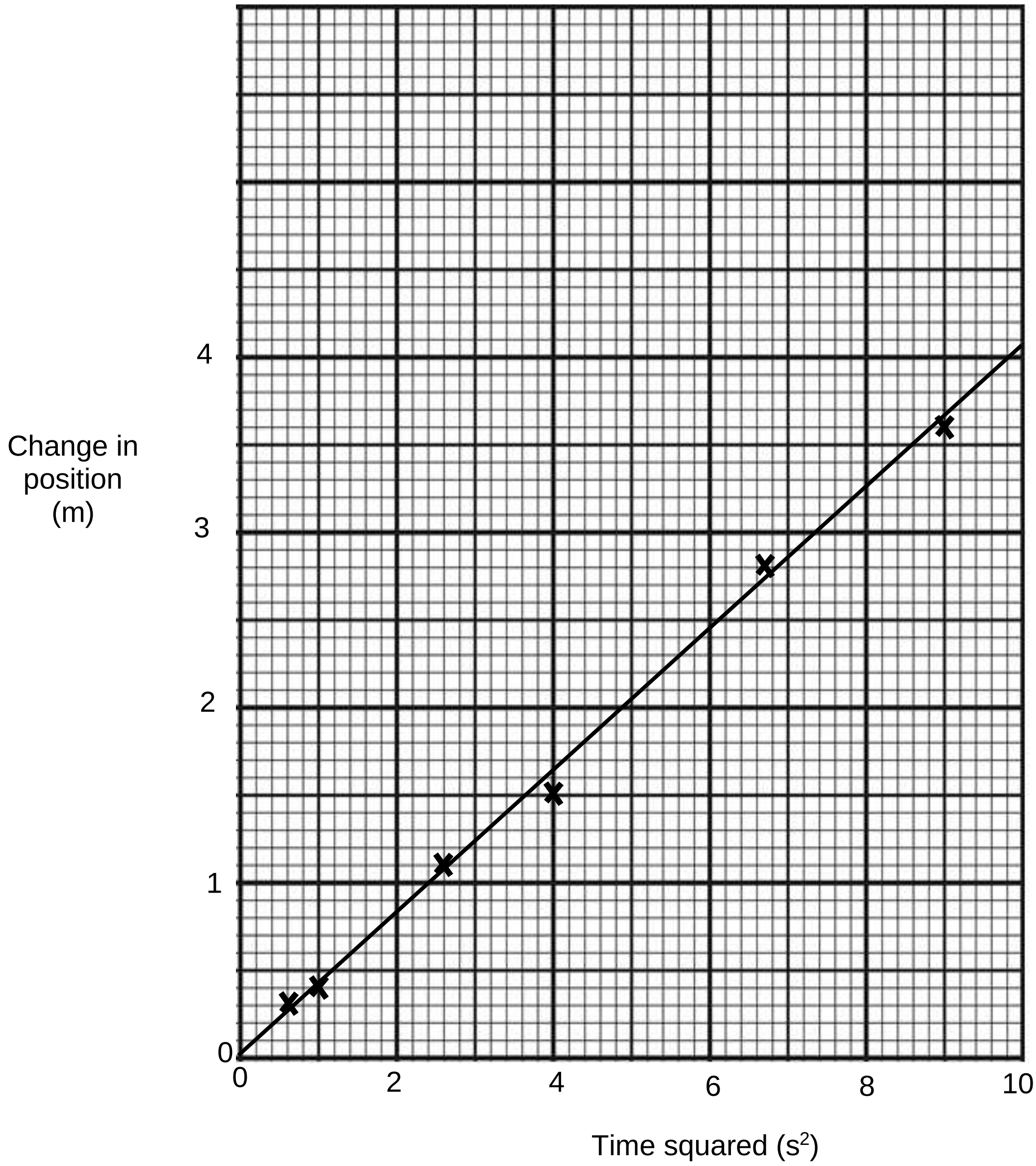
$\therefore$ Gradient = $\frac{1}{2}a$

$\therefore$ $a = 2$ (gradient from 3.4)

$\boldsymbol{a = 0{,}8\ \mathrm{m{\cdot}s^{-2}}}$ *[unit must be given]*

3.6 t^2 = 7,4 (Read t^2 value off graph)
t = 2,7 s (Square root value)

Graph showing the change in position in each time interval squared

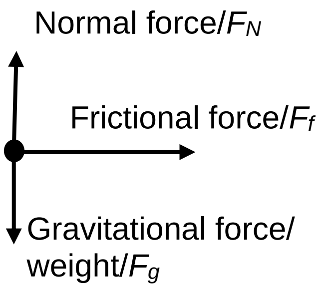


QUESTION 4

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

4.2 There is no F_{NET} as there is no frictional force acting on the book.

4.3



4.4 The book would accelerate / slide / move backwards relative to the passenger.

4.5 $F_{fs}^{max} = \mu_s F_N$

$F_{fs}^{max} = (0,4)\ (0,1 \times 9,8)$

$\boldsymbol{F_{fs}^{max}} = \mathbf{0,39\ N}$

4.6 $F_{net} = ma$

$0,39 = 0,1a$

$\boldsymbol{a} = \mathbf{3,9\ m{\cdot}s^{-2}}$

4.7 The book would slide towards the BACK of the bus because the maximum static frictional forces is insufficient to accelerate the book with the seat.

QUESTION 5

5.1 Acceleration is *the rate of change of velocity.*

5.2 a = gradient of v–t graph

$$= \frac{1,2}{0,5}$$

$$\boldsymbol{a = 2,4\ m{\cdot}s^{-2}}$$

OR

$$v = u + at$$

$$1,2 = 0 + a(0,5)$$

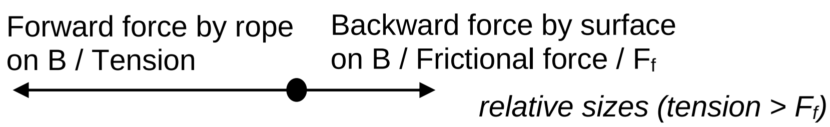
$$\boldsymbol{a = 2,4\ m{\cdot}s^{-2}}$$

5.3 *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.*

OR

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

5.4



5.5 Consider B :

$$T_2 - F_f = m_B a$$

$$T_2 - 19,6 = 5(2,4)$$

$$\boldsymbol{T_2 = 31,6\ N}$$

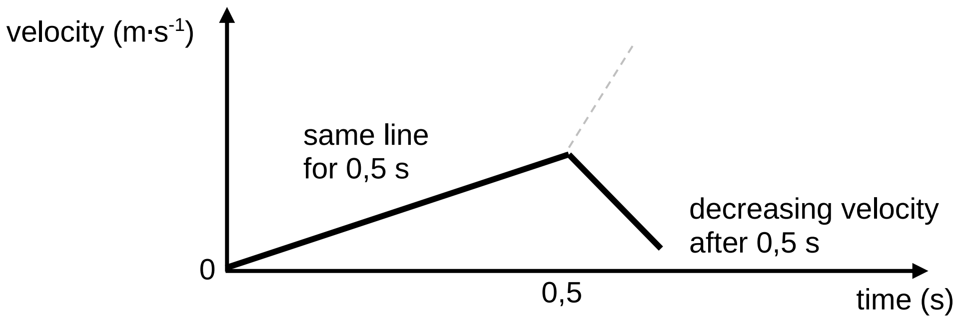
5.6

$$T_1 - (T_2 + F_f) = ma$$

$$T_1 - 31,6 - 3,9 = 1(2,4)$$

$$\boldsymbol{T_1 = 37,9\ N}$$

5.7



QUESTION 6

6.1 Impulse is *the product of the net force and the time for which it acts.*

6.2 $\Delta p = mv - mu$

$= 0{,}8(2) - (0{,}8)(-4{,}5)$

$=$ **5,2 kg.m·s^{-1} OR 5,2 N.s away from the wall**

6.3 $F_{net} = \dfrac{\Delta p}{\Delta t}$

$F_{net} = \frac{5{,}2}{0{,}26}$

$\boldsymbol{F_{net} = 20\ \mathrm{N}}$

6.4 Greater than

6.5 Work–energy theorem: *The work done by a net force on an object is equal to the change in the kinetic energy of the object.*

6.6 $F_{net}s = \Delta E_K$

$(-5{,}5)(0{,}9) = \frac{1}{2}(0{,}8)(0)^2 - \frac{1}{2}(0{,}8)u^2$

u = 3,52 m·s^{-1}

OR $F_{net} = ma$

$5{,}5 = 0{,}8a$

$a = 6{,}88\ \mathrm{m{\cdot}s^{-2}}$

$v^2 = u^2 + 2as$ (both formulae)

$0^2 = u^2 + 2(-6{,}88)(0{,}9)$

u = 3,52 m·s^{-1}

6.7 $\Delta E = E_{K(after)} - E_{K(before)}$

$= \frac{1}{2}mv^2_{(after)} - \frac{1}{2}mv^2_{(before)}$

$= \frac{1}{2}(0{,}8)(3{,}52)^2 - \frac{1}{2}(0{,}8)(5)^2$

$= -5{,}04\ \mathrm{J}$

5,04 J

QUESTION 7

7.1 7.1.1 $F = \dfrac{GM_1M_2}{r^2}$

$$F = \frac{\left(6{,}7\times10^{-11}\right)\left(6{,}4\times10^{23}\right)\left(1{,}48\times10^{15}\right)}{(3{,}39\times10^{6} + 20{,}1\times10^{6})^{2}\ \text{(conversion)}}$$

$\boldsymbol{F = 1{,}15 \times 10^{14}}$ **N**

7.1.2 C Newton's third law

7.2 7.2.1 Electric field is *the force per unit positive charge.*

7.2.2 $F = E.q$

$= (420)\left(6 \times 10^{-6}\right)$

$=$ $\mathbf{2{,}52 \times 10^{-3}}$ **N**

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

7.2.4 $F_g = mg = (3 \times 10^{-3}\text{ kg})(9{,}8) = 29{,}4 \times 10^{-3}$ N (0,0294 N)

$\tan\theta = \dfrac{2{,}52 \times 10^{-3}}{29{,}4 \times 10^{-3}}$ method

$\boldsymbol{\theta = 4{,}90°}$

7.2.5 The angle would increase and the angle would be on the opposite side of the vertical / in the opposite direction in the field.

QUESTION 8

8.1 Emf is *the total energy supplied per coulomb of charge by the cell.*

8.2 $V_{motor} = I_{motor} R_{motor}$
$= (10)(0,05)$
$\boldsymbol{V_{motor} = 0,5\ \mathrm{V}}$

8.3 $P = I^2R$
$55 = I^2(12)$
$\boldsymbol{I = 2,14\ \mathrm{A}}$

8.4 A_1 = total current through headlamps
$= 2,14 + 2,14$
= 4,28 A

8.5 $\frac{1}{R_P} = \frac{1}{R_1} + \frac{1}{R_2}$
$\frac{1}{R_P} = \frac{1}{12} + \frac{1}{12}$

$\boldsymbol{R_P = 6\ \Omega}$

8.6 $emf = I\,(R + r)$
OR $\boldsymbol{emf = 4,28(6 + r)}$

8.7 S_2 closed: $\boldsymbol{emf = 10(0,05 + r)}$

8.8 S_1 closed: $emf = 4,28(6 + r)$
S_2 closed: $emf = 10(0,05 + r)$
$4,28(6 + r) = 10(0,05 + r)$
$25,68 + 4,28r = 0,5 + 10r$
$5,72\,r = 25,18$
$\boldsymbol{r = 4,40\ \Omega}$

$emf = 4,28(6 + r)$
$emf = 4,28(6 + 4,40)$
$\boldsymbol{emf = 44,5\ \mathrm{V}}$

OR $emf = 10(0,05 + r)$
$emf = 10(0,05 + 4,40)$
$\boldsymbol{emf = 44,5\ \mathrm{V}}$

8.9 As the starter motor is added in parallel the overall external (load) resistance decreases. This increases the current through the battery, causing the lost volts to increase which reduces the terminal voltage, which is the voltage across the headlamps, causing the current through them to decrease, causing their brightness to DECREASE.

8.10 If one of the headlamps burns out when they are connected in series, the circuit will be broken and neither will work.
OR If one headlamp burns out when connected in parallel, the other headlamp will still work.

QUESTION 9

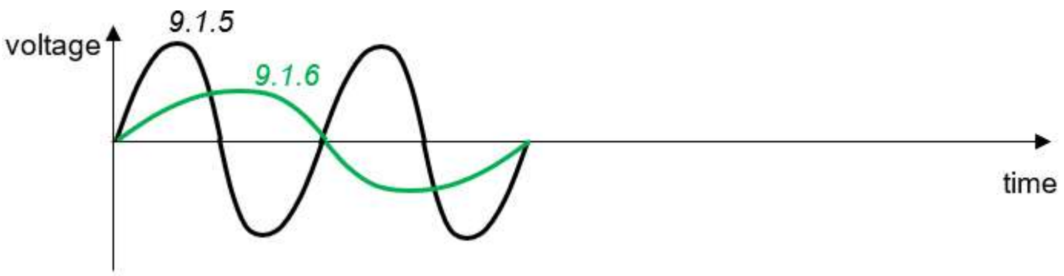
9.1 9.1.1 mechanical energy to electrical energy

9.1.2 bridge rectifier

9.1.3 *Faraday's law states that the emf induced is directly proportional to the rate of change of magnetic flux (flux linkage).*

9.1.4 When the magnet spins, the coil experiences a change in magnetic flux. This induces an emf in the coil, which produces a current in the coil.

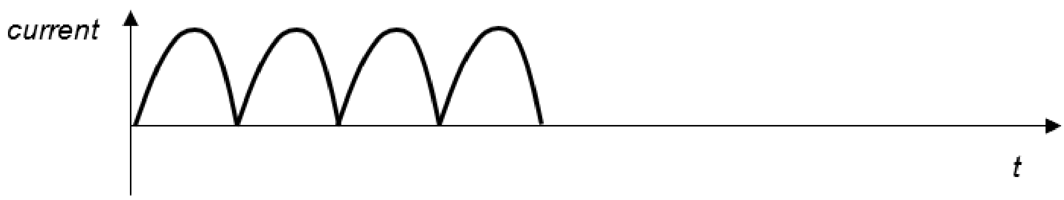
9.1.5



sinusoidal shape
2 cycles (can start at 0 or max)

9.1.6 half the amplitude
half the frequency

9.1.7



shape
all positive (or all negative)

9.2 $\frac{V_P}{V_S} = \frac{N_P}{N_S}$

$\frac{V_P}{240} = \frac{11\,000}{4000}$

V_P = 660 V

QUESTION 10

10.1 *The work function is the minimum amount of energy needed to emit an electron from the surface of a metal.*

10.2 $E = hf$

$E = (6{,}6 \times 10^{-34})(9 \times 10^{14})$

$\boldsymbol{E = 5{,}94 \times 10^{-19}\ \mathrm{J}}$

10.3 energy in eV : $\frac{5{,}94 \times 10^{-19}}{1{,}6 \times 10^{-19}} = 3{,}71\ \mathrm{eV}$

Calcium and sodium will emit light as their work functions are lower than the energy of light of this frequency.

10.4 The same two metals will emit electrons (or calcium **and** sodium). Changing the intensity does not affect the energy of the photons OR changing the intensity affects only the number of photons.

10.5 $\frac{\mathrm{hc}}{\lambda} = W_0 + E_{K(max)}$

$\frac{(6{,}6 \times 10^{-34})(3 \times 10^{8})}{420 \times 10^{-9}} = (2{,}3)(1{,}6 \times 10^{-19}) + \frac{1}{2}(9{,}1 \times 10^{-31})v^2$

$\boldsymbol{v = 4{,}77 \times 10^{5}\ \mathrm{m \cdot s^{-1}}}$

Total: 200 marks