NATIONAL SENIOR CERTIFICATE EXAMINATION
NOVEMBER 2021

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 A
1.4 C
1.5 B
1.6 C
1.7 D
1.8 D
1.9 C
1.10 C

QUESTION 2

2.1 2.1.1 Velocity is the rate of change of position **OR** the rate of displacement **OR** the rate of change of displacement.

2.1.2 $s = ut + \frac{1}{2}at^2$

$25 = 0 + \frac{1}{2}a(5)^2$

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

2.1.3 Both are at position *x* = 25 m **OR** both have displacements of 25 m **OR** they have the same position.

2.1.4 $v_A = u + at$

$v_A = 0 + 2(5)$ *(c.o.e. from 2.1.2)*

$\boldsymbol{v_A = 10\ m \cdot s^{-1}}$

2.1.5 $v_B = \frac{\Delta x}{\Delta t} = \frac{85 - 25}{9 - 5}$ $\boldsymbol{= 15\, m \cdot s^{-1}}$

2.1.6 $s = \frac{1}{2}(u + v)t$

$25 = \frac{1}{2}(0 + 15)t$ *(c.o.e. from 2.1.5)*

$t = 3{,}33\ s$

$t_1 = 5 - t$

$= 5 - 3{,}33$

$\boldsymbol{= 1{,}67\ s}$

2.1.7 At same position at t = 5 seconds.
Car B is moving $5 m \cdot s^{-1}$ faster than car A, so in 7 seconds, car B will move 5 × 7 = 35 m further than car A, so they will be **35 m** apart.

OR Car B: $v_B = 15\ m \cdot s^{-1}$
Car A: $v_A = 10\ m \cdot s^{-1}$

A & B apart by (15 – 10)(12 – 5)
= (5)(7)
= **35 m**

OR Car B $s_B = 25 + 15(7) = 130\ m$
Car A $s_A = 25 + 10(7) = 95\ m$
∴ A & B apart by 130 – 95 = **35 m**

2.2 $s = ut + \frac{1}{2}at^2$

$1{,}7 = u(0{,}15) + \frac{1}{2}(9{,}8)(0{,}15)^2$

$u = 10{,}6\ m \cdot s^{-1}$

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

$(10{,}6)^2 = (0)^2 + 2(9{,}8)s$

$\boldsymbol{s = 5{,}73\ m}$

QUESTION 3

3.1 3.1.1 Displacement is a change in position.

3.1.2 $v = u + at$

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

$\boldsymbol{t = 0{,}2\ s}$

3.1.3 $s = ut + \frac{1}{2}at^2$

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

$\boldsymbol{s = 1{,}0\ m}$

3.1.4 $v^2 = u^2 + 2as$

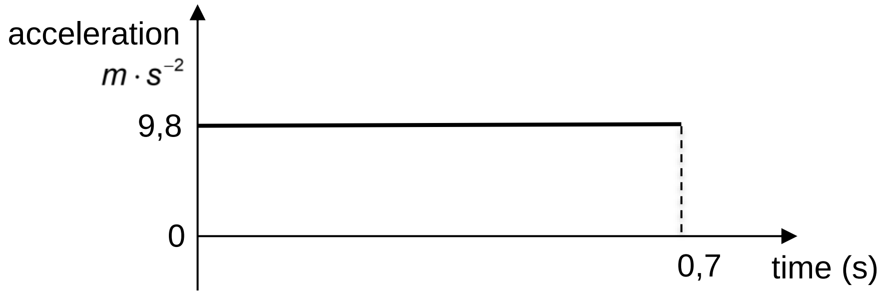
$0^2 = (-2)^2 + 2(9{,}8)s$

$s = -0{,}20\ m$ or 0,20 upwards

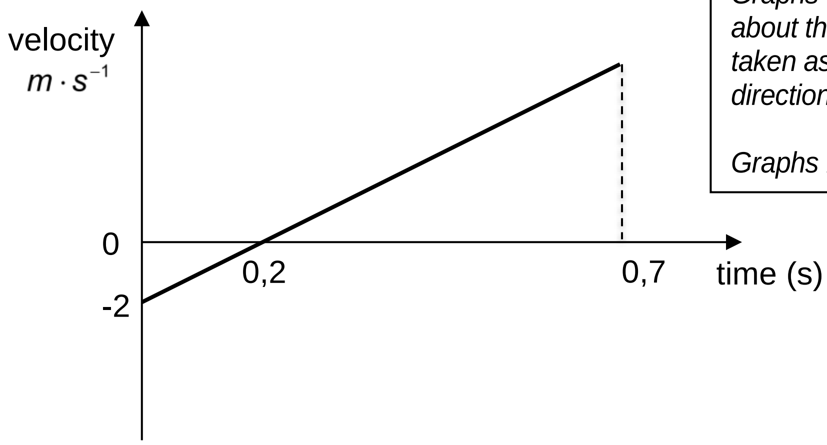
$h = 0{,}20 + 1{,}0$

$\boldsymbol{= 1{,}20\ m}$

3.1.5



3.1.6



Graphs could be reflected about the x-axis if up was taken as the positive direction.

Graphs must correspond.

3.2 Shopper **B** must cover 3 m to be clear of Shopper **A** (1,5 m + 1,5 m).

$$t_{shopper} = \frac{s}{v} = \frac{2}{0,8} = 2,5\ s$$

Shopper **B**:

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

$$3 = (u)(2,5) + \frac{1}{2}(0,48)(2,5)^2$$

$$\boldsymbol{u = 0,6\ m \cdot s^{-1}}$$

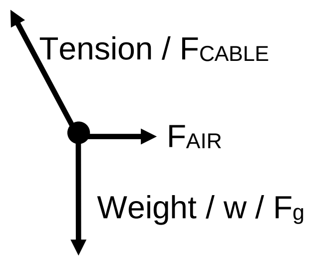
QUESTION 4

4.1 4.1.1 When object A exerts a force on object B, object B simultaneously exerts an oppositely directed force of equal magnitude on object A.

4.1.2 The air exerts force on the hairdryer as the hairdryer exerts a force on the air.

The air exerts force on the hairdryer and the cable is fixed at the top, so is at an angle to the vertical.

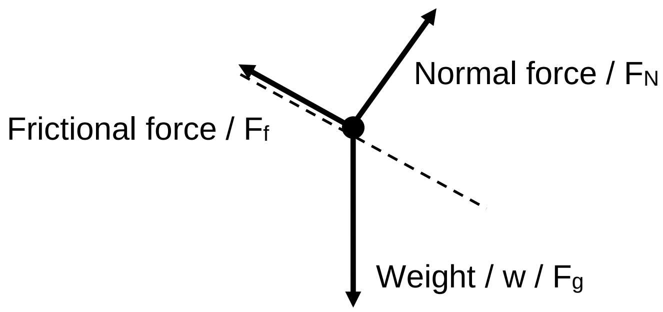
4.1.3



4.1.4

$$F_{AIR} = F_g \cdot \tan 8$$
$$F_{AIR} = (0,6)(9,8) \cdot \tan 8$$
$$\boldsymbol{F_{AIR} = 0,83\ \text{N}}$$

4.2 4.2.1



4.2.2 The force that opposes the motion of an object.

4.2.3

$$F_{fs}^{max} = \mu F_N$$
$$F_{fs}^{max} = (0,6)(10)(9,8)\cos 15°$$
$$\boldsymbol{F_{fs}^{max} = 56,8\ N}$$

4.2.4 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.

4.2.5 $F_{fs}^{max} + mg\sin 15 + F_{APP} = 0$

$-56{,}8 + (10)(9{,}8)\sin 15 + F_{APP} = 0$

$\boldsymbol{F_{APP} = 31{,}44\ N}$ **down the slope**

OR

$mg\sin 15 + F_{APP} = F_{fs}^{max}$

$(10)(9{,}8)\sin 15 + F_{APP} = 56{,}8$

$\boldsymbol{F_{APP} = 31{,}44\ N}$ **down the slope**

4.2.6 $F_{g,par} = \mu F_N$

$mg\sin\theta = 0{,}6(mg\cos\theta)$

$\sin\theta = 0{,}6(\cos\theta)$

$\frac{\sin\theta}{\cos\theta} = 0{,}6$

$\tan\theta = 0{,}6$

$\boldsymbol{\theta = 30{,}96°}$

QUESTION 5

5.1 5.1.1 Impulse is the product of the net force and the contact time.

5.1.2
$$F_{net}\Delta t = m\Delta v$$
$$F_{net}(0,8) = (25)(3,5-(-1,5))$$
$$\boldsymbol{F_{net} = 156,25\ N}$$

5.1.3 The same as

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

5.1.5
$$(E_{mech})_A = (E_{mech})_B$$
$$(25)(9,8)(\ h\ ) = \frac{1}{2}(25)(3,5)^2$$
$$\boldsymbol{h = 0,63\ m}$$

5.2 5.2.1
$$E_K = \frac{1}{2}mv^2$$
$$E_K = \frac{1}{2}(65)(2,5)^2$$
$$\boldsymbol{E_K = 203,13\ J}$$

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

5.2.3
$$W = \Delta E_K$$
$$F_f s = \frac{1}{2}mv_f^2 - \frac{1}{2}mv_i^2$$
$$F_f(2) = \frac{1}{2}(65)(0) - 203,13 \quad \textit{(c.o.e from 5.2.1)}$$
$$F_f(2) = 0 - 203,13 \quad \textit{[can go straight to this step]}$$
$$\boldsymbol{F_f = -101,56\ N}$$ (negative does not have to be there – mag. only)

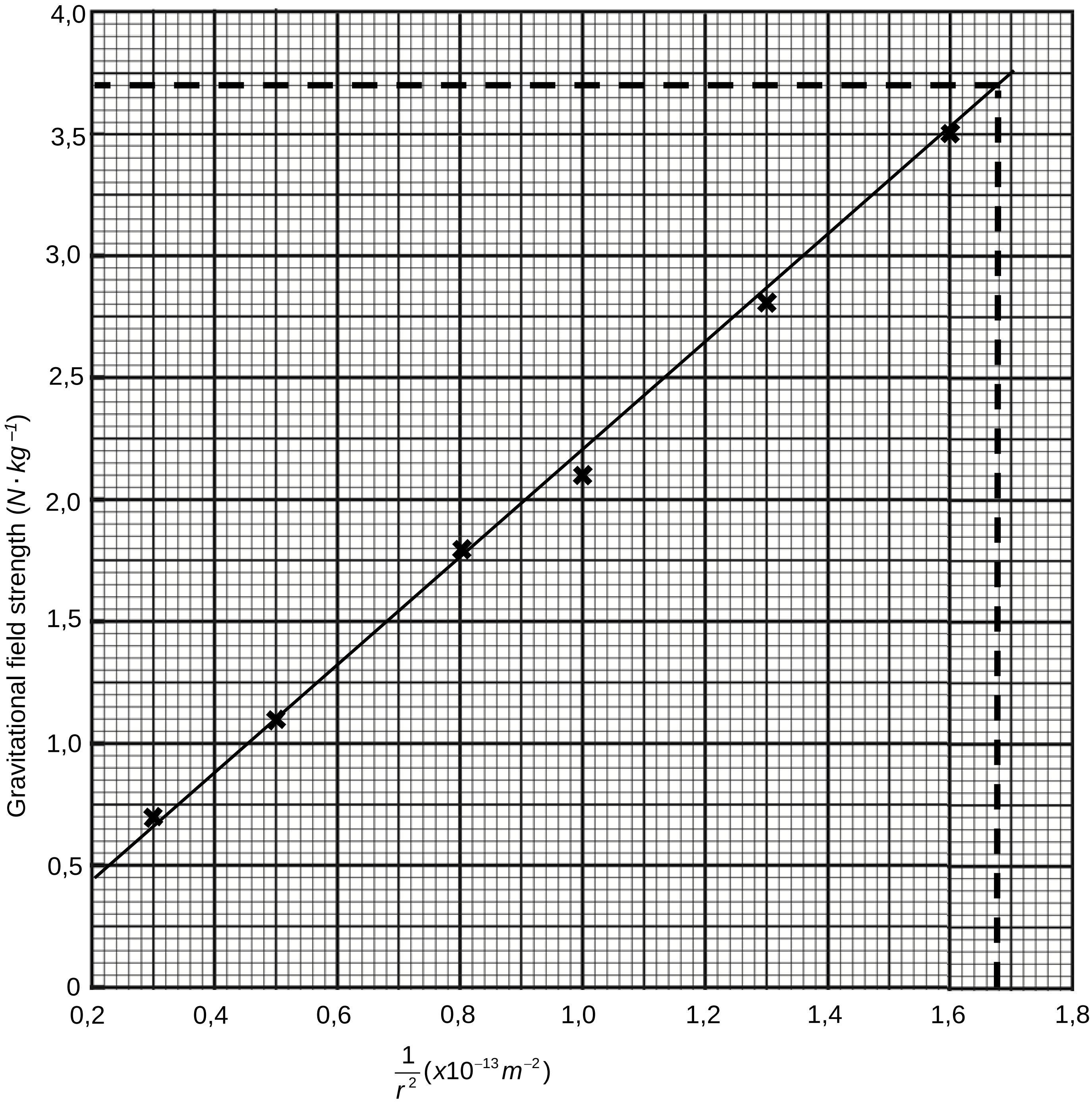
5.2.4
$$s = \frac{1}{2}(u+v)t$$
$$2 = \frac{1}{2}(2,5+0)t$$
$$t = 1,6\ s$$
$$P = \frac{W}{t} = \frac{203,13}{1,6}$$
$$\boldsymbol{P = 126,96\ W}$$

QUESTION 6

6.1 0,8

6.2 Graph – on Answer Sheet
Heading
y-axis title and unit
y-axis scale (plotted points > $\frac{1}{2}$ graph paper)
plotted points
line of best fit

Graph to show gravitational field strength related to $\frac{1}{r^2}$



6.3 $\frac{1}{r^2} = \frac{1}{(2,44 \times 10^6)^2} = 1,68 \times 10^{-13}$

$\mathbf{g_{surface} = 3,7\ N \cdot kg^{-1}}$ **(*allow 3,60 – 3,75*)**

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

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

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

gradient = 2,2 × 10^{13} (accept 2,09 × 10^{-13} to 2,3 × 10^{-13})

6.5 $g = \frac{GM}{r^2} \quad \therefore \ g = GM\frac{1}{r^2}$

gradient $= GM$

$GM = 2,2 \times 10^{13}$

$M = \frac{2,2 \times 10^{13}}{6,7 \times 10^{-11}}$

$\mathbf{M = 3,3 \times 10^{23}\ kg}$

6.6 $E_p = mgh$

$E_p = (5)(3,7)(2)$

$\mathbf{E_p = 37\ J}$

QUESTION 7

7.1 7.1.1 $P = VI$

$750 = 240\ I$

$\mathbf{I = 3,125\ A}$ *(may be rounded to 3,13 A)*

7.1.2 $Cost = \frac{cost \times number\ of\ units}{unit}$

$Cost = \frac{R1,20}{unit} \times (0,75\ kW)(\frac{20}{60}h)$

$Cost = \frac{R1,20}{kWh} \times 0,25\ kWh$

$\mathbf{Cost = R0,30\ \textit{or}\ 30\ c}$

7.2 7.2.1 Emf is the total energy supplied per coulomb of charge by the cell.

7.2.2 0 V

7.2.3 $emf = I(r + R)$

$12 = 1,6(0,5 + R)$

$\mathbf{R = 7\ \Omega}$

7.2.4 $V = IR$ **OR** $V = emf - Ir$

$V = (1{,}6)(7)$ $= 12 - 1{,}6(0{,}5)$

$\boldsymbol{V = 11{,}2\ V}$ $\boldsymbol{= 11{,}2\ V}$

7.2.5 $P = \frac{V^2}{r}$ **OR** $P = I^2r$ **OR** $P = VI$

$P = \frac{(1{,}6 \times 0{,}5)^2}{0{,}5}$ $P = (1{,}6)^2(0{,}5)$ $P = (1{,}6 \times 0{,}5)(1{,}6)$

$\boldsymbol{P = 1{,}28\ W}$

7.2.6 (a) Increase
The current increases because the resistance of the circuit decreases when a resistor is added in parallel.

(b) Increase

(c) Decrease
When the current increases, the "lost volts" (Ir) increase. [This means a smaller V_{term} or voltage across the circuit.]

QUESTION 8

8.1 X

8.2 The <u>interaction</u> of the magnetic field around the current-carrying conductor and the magnetic field of the magnet.

8.3 Change the direction of the magnetic field (turn magnet upside down).
Change the direction of the current (turn the battery around).

8.4 Increase the strength of the magnetic field (stronger magnet)
Increase the current in the conductor
Increase thickness of magnet to increase length of conductor in magnetic field
(Any 2)

8.5 Yes

8.6 There is a changing magnetic field around the alternating current in the primary coil resulting in the secondary coil experience a change in flux inducing an emf which is proportional to the number of turns on the coil. In an ideal transformer, there is no loss in power. (PRIMARY = SECONDARY)

8.7 $\frac{N_S}{N_P} = \frac{V_S}{V_P}$

$\frac{N_S}{200} = \frac{240}{16}$

$\boldsymbol{N_S = 3\ 000\ turns}$

8.8 When high voltage is used, the current is low. Rate of energy loss as heat is reduced when current is low. ($P = I^2R$)

QUESTION 9

9.1 9.1.1 These arrows represent the electron transitions as electrons drop from one energy level to another. (OR electron movement between energy levels)

9.1.2 **B**. Greatest wavelength has lowest energy, which corresponds to the smallest **difference** in energy.

9.1.3 $E = hf$

$-13{,}6 - (-3{,}4) = (\frac{6{,}6 \times 10^{-34}}{1{,}6 \times 10^{-19}})\, f$

$[-13{,}6 - (-3{,}4)] \times 1{,}6 \times 10^{-19} = 6{,}6 \times 10^{34} f$

$\boldsymbol{f = 2{,}47 \times 10^{15}\ Hz}$

energy difference *conversion of eV to J* *substitution* *answer*

9.2 9.2.1 The threshold frequency is the **minimum** frequency of incident radiation at which electrons will be emitted from a particular metal.

9.2.2 $W_0 = hf_0$

$3{,}36 \times 10^{-19} = 6{,}6 \times 10^{-34} f_0$

$\boldsymbol{f_0 = 5{,}09 \times 10^{14}\ Hz}$

9.2.3 $c = f\lambda$

$3 \times 10^{8} = f(470 \times 10^{-9})$

$f = 6{,}38 \times 10^{14}\ Hz$

The frequency of the incident light is greater than the threshold frequency of caesium, so an electron may be ejected.

OR

$E = \frac{hc}{\lambda}$

$E = \frac{(6{,}6 \times 10^{-34})(3 \times 10^{8})}{470 \times 10^{-9}}$

$E = 4{,}21 \times 10^{-19}\ J$

The incident light has greater energy than the work function of caesium, so an electron may be ejected.

Total: 200 marks