NATIONAL SENIOR CERTIFICATE EXAMINATION
MAY 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 MULTIPLE CHOICE

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

QUESTION 2 KINEMATICS

2.1 2.1.1 Rate of change of distance

2.1.2 speed = $\frac{\Delta x}{\Delta t} = \frac{0,4}{8}$ = 0,05 m·s^{-1}

2.1.3 0,05 = $\frac{\Delta x}{3,2}$ hence Δx = 0,16 m (16 cm)

2.2 **Tortoise A:** $\Delta x = 50 + 16 + 30 = 96 \text{ cm} = 0,96 \text{ m}$

$\Delta x = v_i \Delta t + 1/2a\Delta t^2$

0,96 = 0,05 Δt $+ 1/2a\Delta t^2$

Tortoise B: $\Delta x = v_i \Delta t + 1/2a\Delta t^2$

0,5 = 0,05 (coe) Δt

Δt = 10 s

Method (substitution /coe)

0,96 = 0,05 (10) + ½ a (10)^2

a = 0,0092 m·s^{-2}

QUESTION 3 KINEMATICS

3.1 3.1.1 (a) $a = \dfrac{-0{,}02 - 0}{1 - 0} = -0{,}02\ \text{m.s}^{-2} = 0{,}02\ \text{m.s}^{-2}$ east

(b) $a = \dfrac{0 - 0{,}01}{7 - 6} = -0{,}01\ \text{m.s}^{-2} = 0{,}01\ \text{m.s}^{-2}$ east

3.1.2 (a) 3 – 3,5 s decreasing velocity east accelerating west (or constant negative acceleration)

(b) 5 – 6 s constant velocity west

3.1.3 Displacement is the change in position of an object including direction.

3.1.4 displacement = ½ (2 + 3,5)(–0,02) + ½ (1 + 2,5) (0,01)

(give mark if + or –)

= $3{,}75 \times 10^{-2}$ m east

or ½ (1)(–0,02) + (2)(–0,02) + ½ (0,5)(–0,02) + ½ (0,5)(0,01) + (1)(0,01) + ½ (1)(0,01)

= $3{,}75 \times 10^{-2}$ m east

3.1.5 $v_{ave} = (3{,}75 \times 10^{-2}) / 7 = 0{,}0054\ \text{m·s}^{-1}$ (no direction needed)

3.1.6 See Answer Sheet Memo

3.2 Car A : $\Delta x = 10\ \Delta t$ Car B : $3\ 000 - \Delta x = 15\ (\Delta t - 2(60))$

$3\ 000 - 10\Delta t = 15\Delta t - 1800$ (method simultaneous eqns)

hence $\Delta t = 192$ s and the cars pass at 10:03 (to the nearest minute)
(accept '3 minutes after A started)

$\Delta x = 10\ (192) = 1\ 920$m

and cars meet 1 920 m right of X.

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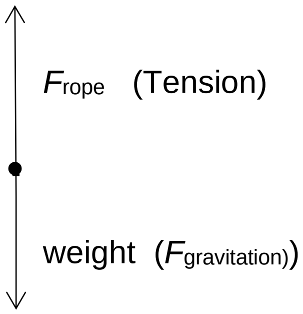
QUESTION 4 NEWTON'S LAWS

4.1 When a net force is applied to a body the body will accelerate in the direction of the net force. The acceleration is directly proportional to the magnitude of the net force and inversely proportional to the mass of the object.

OR

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

4.2



$F_T > F_g$

4.3 $F_{net} = ma$ or implied

$7\,000 - m(9,8) = m\,(1,5)$

hence $m = 619,47$ kg

4.4 $T = mg = 619,47\ (9,8) = 6\,070,80$ N

4.5 down

4.6 $a = \dfrac{v_f - v_i}{\Delta t} = \dfrac{0 - 2,5}{4} = -0,63\ \text{m·s}^{-2}$

4.7 $ma = T - mg$

$619,47\ (-0,63) = T - 6\,070,8$

$T = 5\,680$ N

4.8 If body A exerts a force on body B, then body B simultaneously exerts a force on body A which is equal in magnitude but opposite in direction.

4.9
- The force of the cow on the harness (down) and the force of the harness on the cow (up) OR
- The force of the helicopter on the rope (up) and the force of the rope on the helicopter (down) OR
- The gravitational force of the earth on the cow (down) and the gravitational force of the cow on the earth (up)

QUESTION 5 MOMENTUM, WORK, ENERGY AND POWER

5.1 5.1.1 $p_{before} = p_{after}$

$0 = Mv_{cannon} + mv_{ball}$

$0 = 1\,000mv_{cannon} + 80$ m

$V_{cannon} = 0{,}08$ m·s^{-1} left

5.1.2 Impulse is the product of the net force and the time over which it acts.

5.1.3 $\Delta p = 96 = mv_f - mv_i \Delta p = 96 = -mv_f - mv_i$

96 = m(80) – 0

m = 1,2 kg

5.2 5.2.1 zero

5.2.2 $F_{net} = 0 = F_{applied} - F_{friction}$

$F_{friction} = F_{applied}$ (concept)

$$P = \frac{W}{t} = \frac{F\Delta x}{\Delta t} = F\text{v}$$

$200 = F_f \cdot 1{,}5$

$F_f = 133{,}33$ N

5.2.3 $W = F\Delta x$

= -133,33 (c/o)·3 000

=- 400 000 J (also accept + 400 000J)

5.2.4 $F_{g\ parallel} = mg \sin 6°$

= (55 + 65) (9,8) sin 6°

= 122,93 N

5.2.5 $Fv = P$

(133,33 + 122,93) v = 200

v = 0, 78 m·s^{-1}

5.2.6 decrease

5.2.7 A bigger mass means the friction increases hence more energy is used (work done) to overcome friction and not as much energy is available to power the motion ⇒ range will decrease.

QUESTION 6

6.1 6.1.1 $Q = Ne = 20 \times 1,6 \times 10^{-19} = 3,2 \times 10^{-18}$ C

6.1.2 $F_g = mg = 9,0 \times 10^{-16} \times 9,8 \times 2 = 1,76 \times 10^{-14}$ N

6.1.3 The magnitude of an electric field is defined as the force experienced per unit positive charge (per coulomb of charge)

6.1.4 $E = \frac{F}{q} = \frac{1,76 \times 10^{-14}}{3,2 \times 10^{-18}}$ = $5,51 \times 10^{3}$ N.C^{-1}

6.1.5 $F = k\frac{q_1 q_2}{r^2}$

$= \frac{9 \times 10^{9} \times 4,0 \times 10^{-17} \times 4,0 \times 10^{-17}}{0,01^2}$

$= 1,44 \times 10^{-19}$ N repulsion

6.2 $\frac{G\not{M}.2\not{M}}{X^2} = \frac{G\not{M}.3\not{M}}{Y^2}$ method – for equating forces

$\frac{2}{X^2} = \frac{3}{Y^2}$

$Y = \sqrt{\frac{3x^2}{2}}$ = or 1,22 x

QUESTION 7

7.1 7.1.1 $19{,}36 \times 10^{-2}$ or 0,1936

7.1.2 See Answer Sheet Memo

7.1.3 $\frac{\Delta y}{\Delta x} =$

check two points on graph and if not shown on graph only give one mark

(check points on graph)

$= 6786\ \text{J.A}^{-2}$ (accuracy in range 6616–6956)

7.1.4 $W = I^2 R_H t$

$W / I^2 = 6\,091{,}37$ (c/o) $= R_H t$

$6\,091{,}37 = R_H\ (2 \times 60)$

$R_H = 50{,}76\ \Omega$

7.1.5 $R_{total} = \frac{V}{I} = \frac{48}{0{,}61} = 78{,}69\ \Omega$

hence $R_{\text{rheostat}} = 78{,}69 - 50{,}76$ (c/o)(method -subtracting) $= 27{,}93\ \Omega$

hence V across rheostat = 48 – 30,96 = 17,04 V

OR V across $R_H = 50{,}76(0{,}61)$ (c/o) = 30,96 V

Hence $V_{\text{rheostat}} = 48 - 30{,}96$ (method subtracting) = 17,04 V

7.2 7.2.1 *emf* is the maximum/total amount of energy that a cell is able to provide per coulomb of (positive) charge (or per unit charge).

7.2.2 12 V

7.2.3 $I = \frac{V}{r} = \frac{10}{20} = 0{,}5\ \text{A}$

$emf = VI + Ir$

$12 = 10 + 0{,}5\,r$

$r = 4\ \Omega$

QUESTION 8

8.1 8.1.1 slip rings

8.1.2 clockwise

8.1.3 Fleming's left-hand (motor) rule or right-hand vector rule

8.1.4 See Answer Sheet Memo

8.2 8.2.1 C

8.2.2 A

8.2.3 A

8.2.4 A

8.2.5 B

8.3 8.3.1 step down transformer

8.3.2 cell phone or laptop charger, speaker, doorbell, TV

8.3.3 $\frac{V_s}{V_p} = \frac{N_s}{N_p}$

$\frac{V_s}{220} = \frac{15}{300}$

$V_s = 11\text{ V}$

QUESTION 9

9.1 9.1.1 $2,2 \times 1,6 \times 10^{-19} = 3,52 \times 10^{-19}$ J

9.1.2 $f = \frac{E}{h} = \frac{3,52 \times 10^{-19} \quad (\text{c/o})}{6.6 \times 10^{-34}} = 5,33 \times 10^{14}$ Hz

9.1.3 yellow – green

9.1.4 Work function is the minimum energy required by a photon of incident radiation that will result in an electron being emitted from the surface of a metal.

9.1.5 $E_k = hf - W_o$

$= (6,6 \times 10^{-34})\ (8,9 \times 10^{14}) - 4,59 \times 10^{-19}$

$= 1,28 \times 10^{-19}$ J

9.1.6 If light was a wave, increasing the intensity of light would eventually result in the emission of a photo electron from the surface of a metal for light of any frequency, because energy would build up on the metal. The fact that electrons are only emitted when frequency increases above a certain level and are still emitted if intensity is very low, proves that light interacts with metal in discrete bundles that will each only emit electrons if their energy is enough.

9.2 $10,4 - x = 1,5$ and $9,8 - x = 0,9$ and $8,9 - 6,7 = 2,2$ eV

x = 8,9 eV

Total: 200 marks