NATIONAL SENIOR CERTIFICATE EXAMINATION
MAY 2022

# PHYSICAL SCIENCES: PAPER I

## MARKING GUIDELINES

Time: 3 hours 200 marks

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**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.**

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## QUESTION 1

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

**[10 × 2 = 20]**

## QUESTION 2

2.1 2.1.1 Rate of change of velocity. ✓✓ (2)

2.1.2 $F_{friction}$ $F_{gravitation}$ ✓✓ forces and labels

(2)

2.1.3 (i) $\Delta X_{DART}(h) = 20\,t$ ✓ $+ \frac{1}{2}(-9{,}8$ ✓$)t^2$

**OR** $\Delta X_{DART}(h) = 20(t-1)$ ✓ $+ \frac{1}{2}(-9{,}8$ ✓$)(t-1)^2$

(1 mark only as instructions regarding t not followed) (2)

(ii) $\Delta X_{BALL}\ (h) = 20(t+1)$ ✓ $+ \frac{1}{2}(-12$ ✓$)(t+1)^2$

**OR** $\Delta X_{BALL}\ (h) = 20\,t$ ✓ $+ \frac{1}{2}(-12$ ✓$)t^2$ (2)

2.1.4 (i) $\Delta X_{DART} = \Delta X_{BALL}$ ✓ (mark for equating/method)

$20\,t - 4{,}9\,t^2 = 20\,t + 20 - 6\,t^2 - 12\,t - 6$ ✓

$1{,}1\,t^2 + 12\,t - 14 = 0$ ✓

$t = 1{,}06$ s ✓ (3)

(ii) $h = 20(1{,}06)$ ✓ $- \frac{1}{2}(9{,}8)(1{,}06)^2$ ✓ $= 15{,}69$ m ✓ (3)

**OR** $20\,t - 20 - 4{,}9\,t^2 + 9{,}8\,t - 4{,}9 = 20\,t - 6\,t^2$ ✓

$1{,}1\,t^2 + 9{,}8\,t - 24{,}9$ ✓

Hence $t = 2{,}06$ s (time for ball to reach X)

And time for dart to reach X = 1,06 s ✓

$h = 20(1{,}06)$ ✓ $- \frac{1}{2}(9{,}8)(1{,}06)^2$ ✓ $= 15{,}69$ m ✓

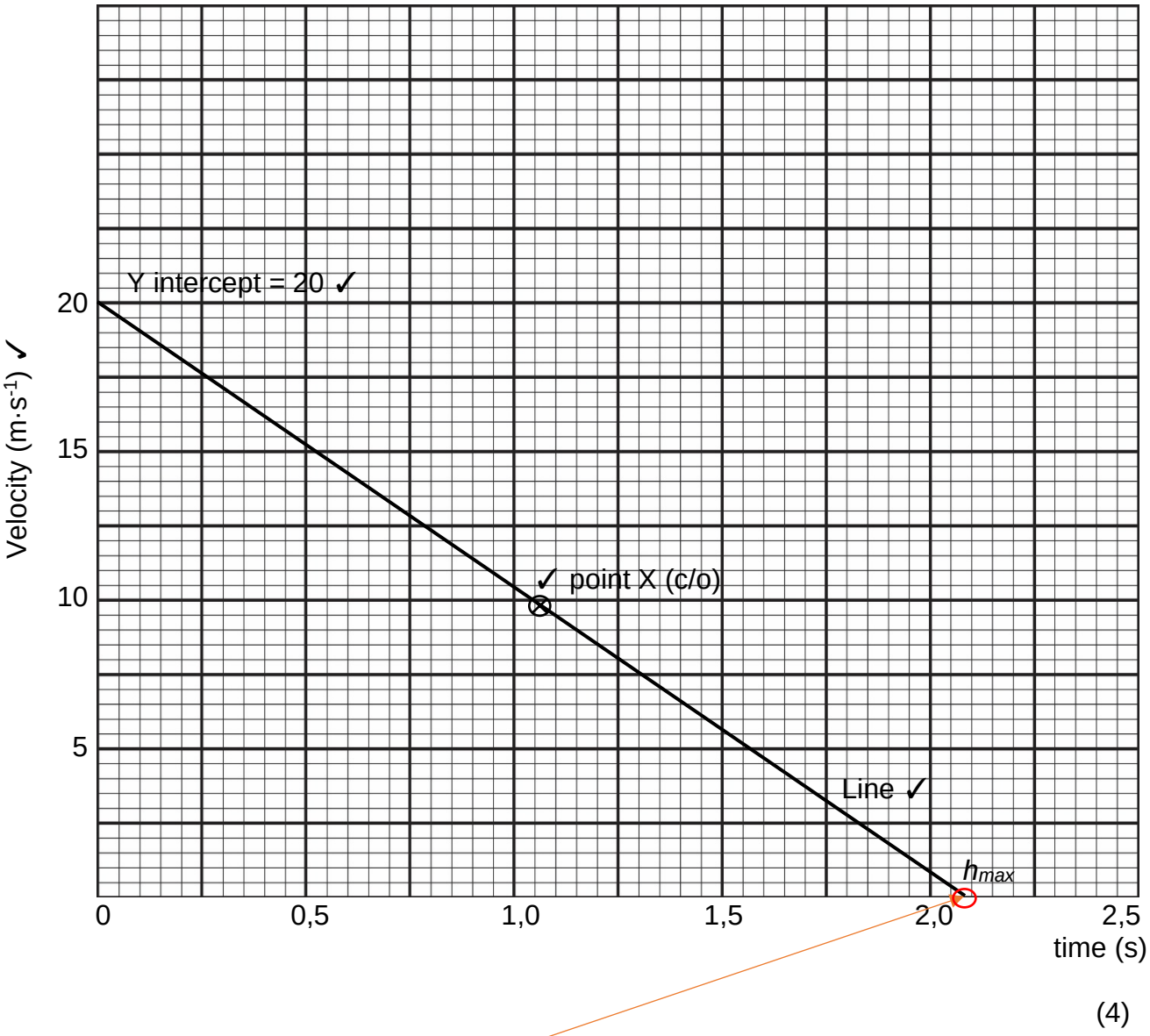
2.1.5 $v_f^2 = v_i^2 + 2a\Delta X_{DART}$ ✓ **OR** $v_f = v_i + a\Delta t$ ✓

$v_f^2 = 20^2$ ✓ $+ 2(-9{,}8)(15{,}69)$ ✓

$v_f = 9{,}62\ \text{m·s}^{-1}$ ✓ (4)

2.1.6 **Graph showing the relationship between velocity and time for A**




(4)

2.1.7 Time at max height = 2,07 s ✓ (c/o from graph) ✓ accuracy (2)

2.1.8 $\Delta X = \frac{1}{2}$ base × height

$= \frac{1}{2}(2{,}05)(20)$ ✓

= 20,5 m ✓ (2)

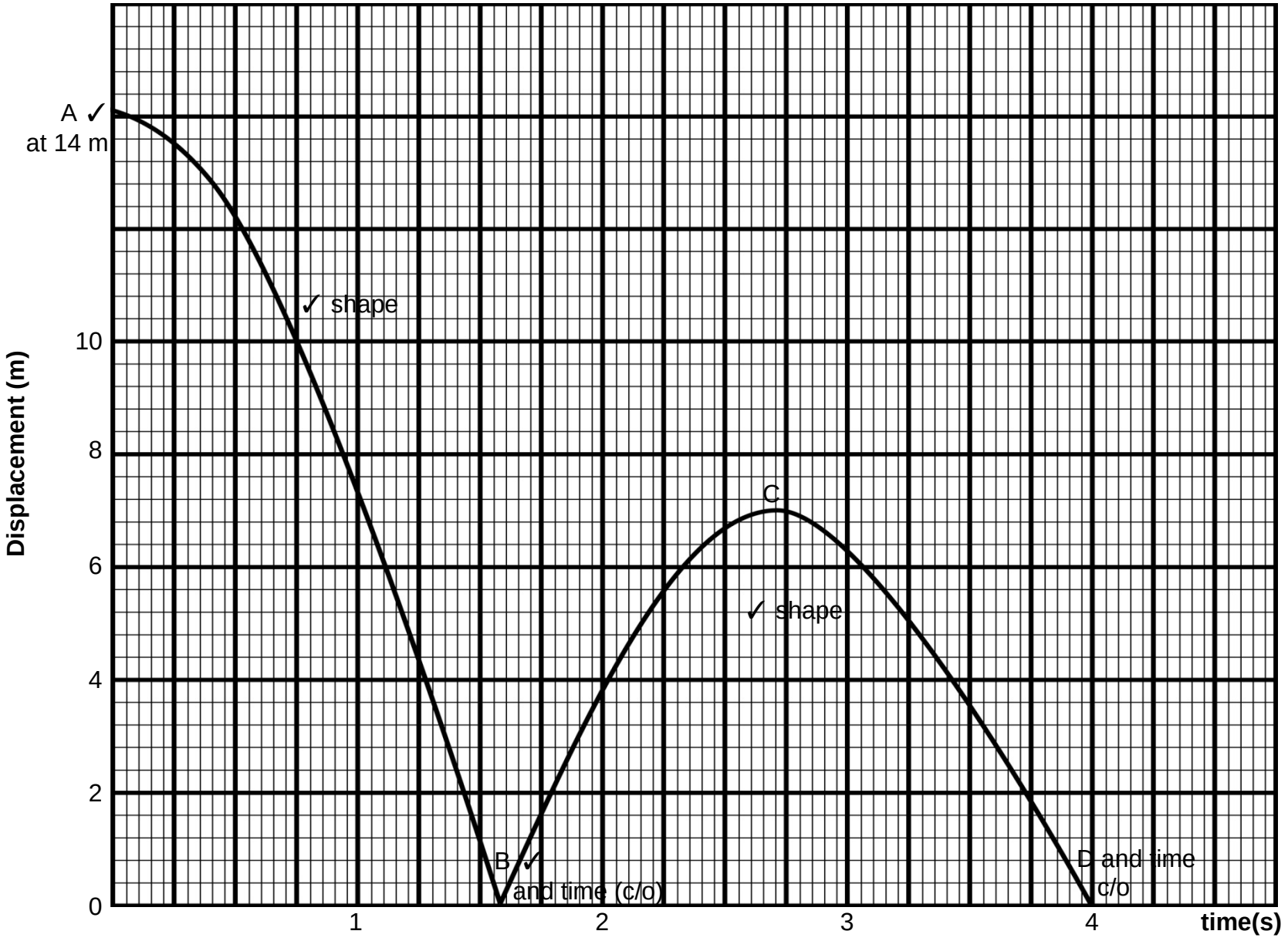
2.2 2.2.1 $\Delta X = vi\,\Delta t + \frac{1}{2}a\Delta t^2$ ✓

$14 = \frac{1}{2}(9{,}8)$ ✓ $\Delta t^2$

$\Delta t$ = 1,69 s ✓ (3)

2.2.2 **Graph showing relationship between displacement and time for a ball that is dropped and allowed to bounce**




C & D ✓

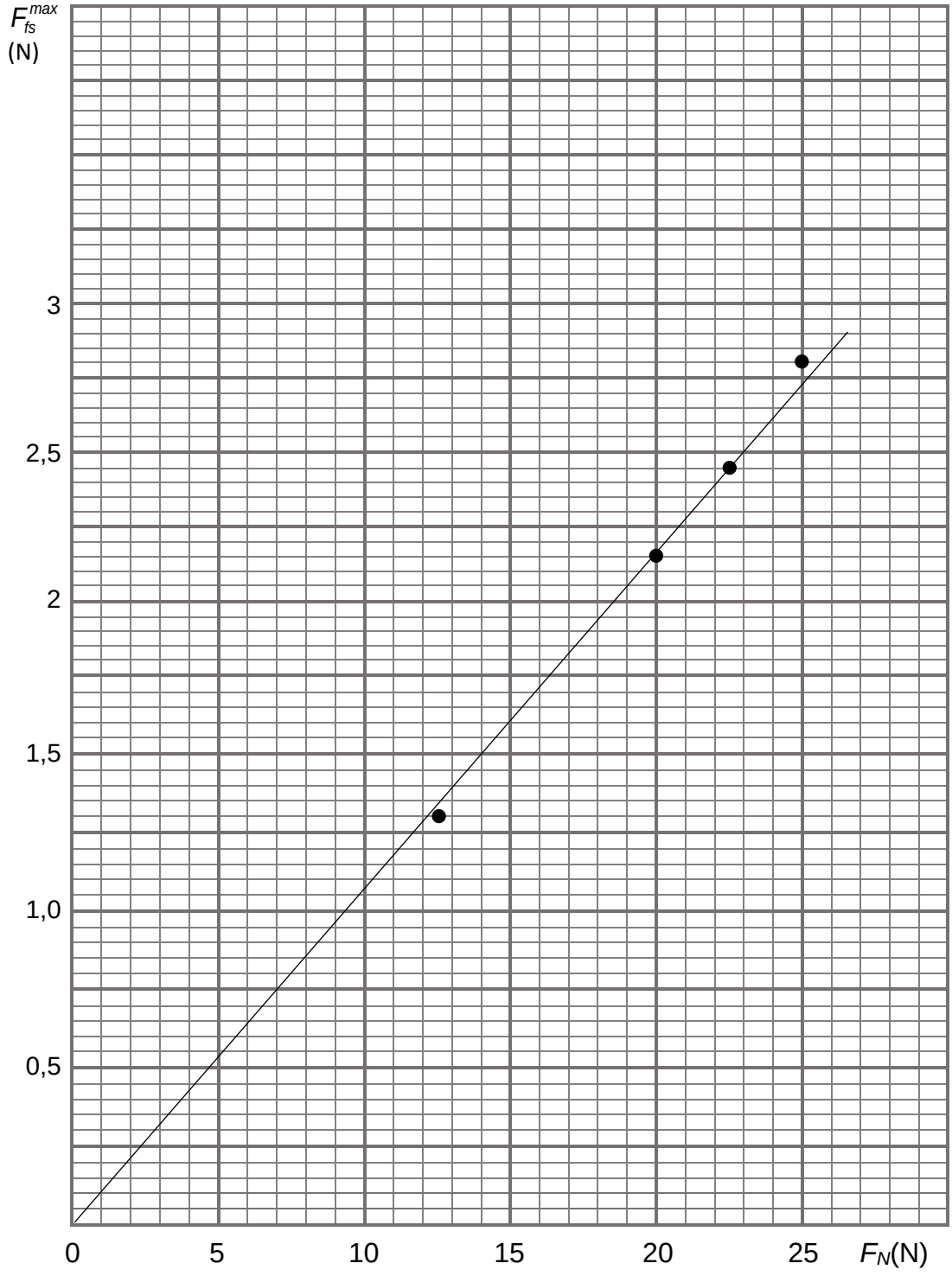
(5)

**[34]**

## QUESTION 3

3.1 3.1.1 The perpendicular force ✓ exerted on an object by a surface in contact with it. ✓ (2)

3.1.2 **Graph showing the relationship between the maximum force of kinetic friction and the normal reaction force for a brick on a surface**

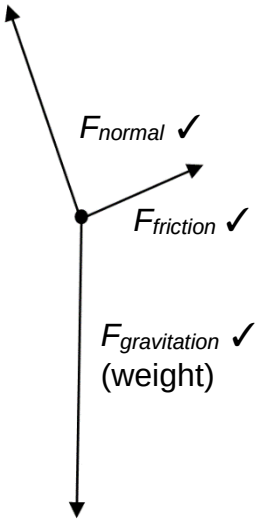



✓ heading ✓ *x*-axis label and unit
✓ *y*-axis label and unit ✓ scale
✓ plotting ✓ best fit ✓ through origin (7)

3.1.3 Gradient of graph = $\mu_s$ ✓ method

$$\text{Gradient} = \frac{\Delta y}{\Delta x} = \frac{2,75 - 1,1}{25 - 10} \checkmark = 0,11 \checkmark \quad (4)$$

3.1.4




(3)

3.1.5 $F_N = mg\cos\theta$ ✓✓ (2)

3.1.6 $F_{fs}^{max} = mg\sin\theta$ ✓✓ (2)

3.1.7 $\mu_s = \frac{F_{fs}^{max}}{F_N}$ ✓ $= \frac{1,3 \times 9,8 \times \sin\theta}{1,3 \times 9,8 \times \cos\theta}$

$\tan\theta$ ✓ = 0,48 ✓

$\theta$ = 25,64° ✓ (4)

3.2 3.2.1 $F_{hX} = X\cos 25°$ ✓✓ (2)

3.2.2 The net force is the single force that has the same effect as the original forces acting together. ✓✓ (2)

3.2.3 $F_{net(3\ kg)} = X\cos 25° - F_{due\ to\ 6\ kg} - F_f$ (✓✓ all or nothing) (2)

3.2.4 $F_{net(6\ kg)} = F_{due\ to\ 3\ kg} - F_f$ (✓✓) (2)

3.2.5 3(1,5) ✓ = $X\cos 25° - 2 - F_{due\ to\ 6\ kg}$

✓ (application of $F_{net} = ma$)

6(1,5) ✓ = $F_{due\ to\ 3\ kg} - 2$

$F_{due\ to\ 6\ kg}$ = 11 N ✓

4,5 = 0,91 $X$ – 2 – 11

$X$ = 19,23 N ✓ (5)

**[37]**

## QUESTION 4

4.1 4.1.1 The energy an object has as a result of its motion. ✓✓ (2)

4.1.2 $E_k = \frac{1}{2}mv^2$ ✓

$= \frac{1}{2}(40)(0,5)^2$ ✓

$= 5$ J ✓ (3)

4.1.3 $E_p + E_{k\,at\,A} + W_f = E_p + E_{k\,at\,B}$

$40(9,8)(20)$ ✓ + 5 (c/o) ✓ + $W_f$ ✓ = ½ $(40)(19,24)^2$ ✓

$W_f = -441,45$ J ✓ (5)

4.1.4 The product of the net force and the time over which it acts. ✓✓ (2)

4.1.5 $F_{net}\Delta t = \Delta p$ ✓

$F_{net}$ 1,4 ✓ $= mv_f - mv_i$

$= 40(0 - 19,24)$ ✓

$F_{net} = 549,71$ N ✓ left ✓ (5)

4.2 4.2.1 The total linear momentum of an isolated system remains constant. ✓✓ (2)

4.2.2 $m_t\,v_{it} + m_{board}\,v_{i\,board} = (m_t + m_{board})v_f$

$45(1,5)$ ✓ + $5(-3,0)$ ✓ = $50\,v_f$ ✓

$v_f = 1,05$ m·s$^{-1}$ ✓ right ✓ (5)

**[24]**

## QUESTION 5

5.1 5.1.1 $F = G\frac{m_1 m_2}{r^2}$ ✓

$\frac{6,7 \times 10^{-11} \times 7,16 \times 10^{22} \times 5,97 \times 10^{24}}{\left(3,84 \times 10^{8}\right)^2}$ ✓ $(\text{conversion to } m)$ ✓

$F = 1,94 \times 10^{20}$ N ✓ (4)

5.1.2 $g = \frac{GM}{r^2}$

4,9 ✓ $= \frac{6,7 \times 10^{-11} \times 5,97 \times 10^{24}}{r^2}$ ✓

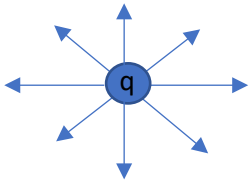
$r = 9,03 \times 10^6$ m ✓

Height above surface = $9,03 \times 10^6 - 6,38 \times 10^6$ (✓ method)

$= 2,65 \times 10^6$ m ✓ (5)

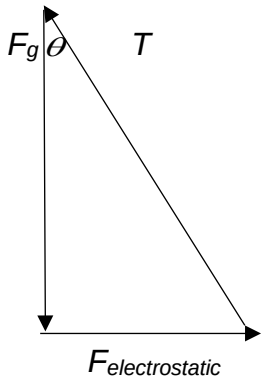
5.2 5.2.1 The force per unit positive charge.✓✓ (2)

5.2.2 

(shape/radial ✓ direction c/o ✓) (2)

5.2.3 $q = \frac{F}{E} = \frac{0,07}{3\times10^{5}}$ ✓ ✓ = $6 \times 10^{-6}$ C ✓ positive ✓ (4)

5.2.4 zero N ✓✓ (0) (2)

5.2.5 


(i) $T^2 = ((0,004)(9,8))^2 + 0,07^2$ ✓
$T = 0,08$ N ✓ (2)

(ii) $\tan\theta = \frac{0,07}{0,004 \times 9,8}$ ✓ hence $\theta = 60,75^{o}$ ✓ (3)

**[24]**

## QUESTION 6

6.1 6.1.1 The maximum amount of energy per coulomb of (positive) charge ✓ supplied by the cell. ✓ (2)

6.1.2 10 V ✓✓ (2)

6.1.3 $I = \frac{emf}{R+r}$ ✓

$= \frac{10}{60 \checkmark + \checkmark 5}$ = 0,15 A ✓ (4)

6.1.4 $V_2 = RI$ = 30 (0,15 ✓c/o) = 4,50 V ✓ (2)

6.1.5 Increase ✓ (1)

6.1.6 less than✓ (1)

6.1.7 When $S_2$ is closed NO CURRENT ✓ flows through $R_2$ because it is a short circuit ✓ (or current takes the path with negligible resistance)
Thus $V = RI$ ✓ = 0 (3)

6.2 6.2.1 It means that 1 500 J of energy ✓ is transferred per second. ✓ (2)

6.2.2 $I = \frac{P}{V}$ ✓ hence $I_{total} = \frac{1\ 500}{220}$ ✓ + $\frac{1\ 800}{220}$ ✓ = 15,0 A ✓ (4)

6.2.3 $R = \frac{V^2}{P}$ ✓

- $V$ is the same for both ✓
- Hence if $P$ is smaller $R$ will be higher ✓ (noting that it has to do with power)
- Hence kettle has higher $R$ ✓ (4)

**[25]**

## QUESTION 7

7.1 Kinetic/mechanical to electrical ✓✓ (2)

7.2 A to B ✓ ✓ (2)

7.3 Flemmings ✓ right hand dynamo rule ✓ (2)

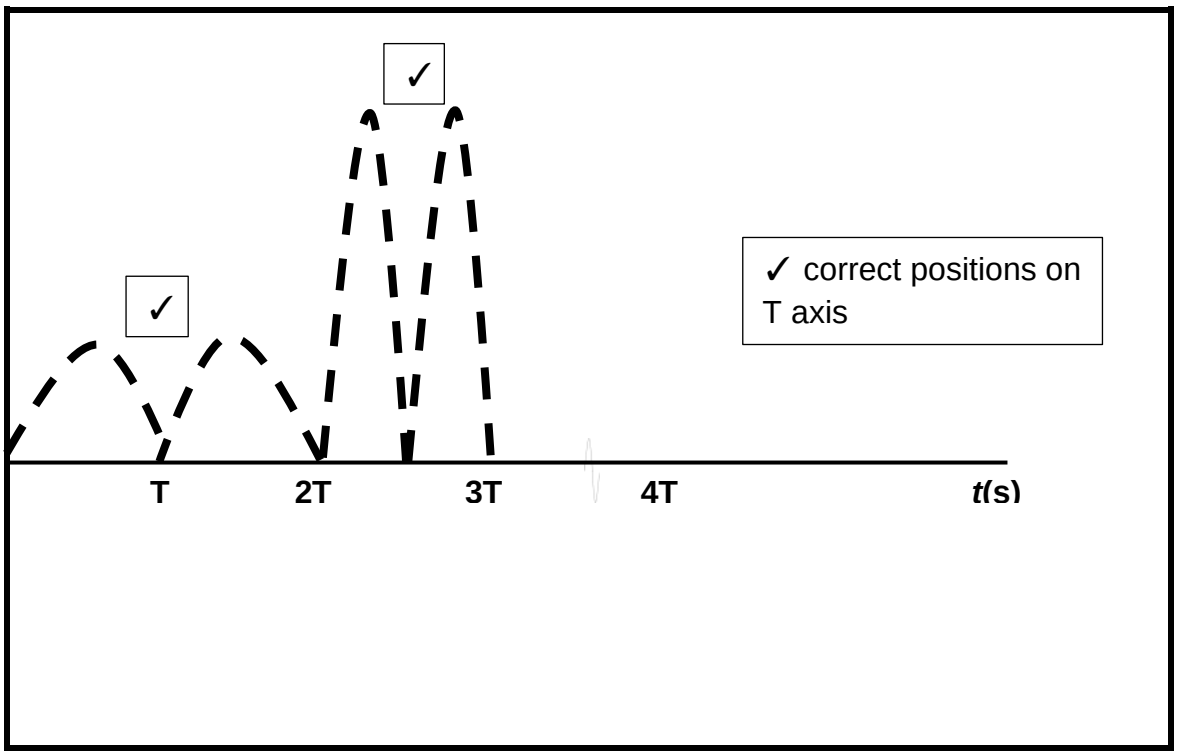
7.4 North ✓✓ (2)

7.5 Moved coil faster ✓✓ (2)

7.6 Current that changes direction (polarity) every half turn ✓✓ (2)

7.7 Full-wave ✓ rectifier ✓ (2)

7.8




(3)

**[17]**

## QUESTION 8

8.1 8.1.1 $\lambda = \frac{c}{f} = \frac{3 \times 10^8}{7{,}81 \times 10^{14}}$ ✓✓

$= 3{,}84 \times 10^{-7}$ m ✓ or 384 nm (3)

8.1.2


**384 nm ✓✓ correct relative position** (2)

8.1.3 Transition 2 ✓ (1)

8.1.4
- Shorter wavelength (higher *f*) means greater energy ✓ photon.
- The greater the photon energy, the bigger the energy difference ✓ between levels. (2)

8.2 8.2.1 The process that occurs when light strikes a metal and electrons are emitted. ✓✓ (2)

8.2.2 $4{,}50 \times 10^{-19}$ J ✓✓ (2)

8.2.3 $W_0 = hf_0$ ✓

$4{,}5 \times 10^{-19}$ ✓ $= 6{,}6 \times 10^{-34} \times f_0$

$f_0 = 6{,}82 \times 10^{14}$ Hz ✓ (3)

8.2.4 $hf = hf_0 + \frac{1}{2}mv^2$

$6{,}6 \times 10^{-34}\ (6 \times 10^{15})$ ✓ $= 4{,}5 \times 10^{-19}$ ✓ + ½ $(9{,}3 \times 10^{-31})$ ✓ $v^2$

$v = 2{,}78 \times 10^6$ m·s$^{-1}$ ✓ (4)

**[19]**

**Total: 200 marks**