NATIONAL SENIOR CERTIFICATE EXAMINATION
NOVEMBER 2013

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	B	(2)	1.6	A	(2)
1.2	C	(2)	1.7	D	(2)
1.3	D	(2)	1.8	A	(2)
1.4	A	(2)	1.9	C	(2)
1.5	B	(2)	1.10	D	(2)

[20]

QUESTION 2 ACCIDENT

2.1 The (total) momentum of an isolated (OR a closed) system (of interacting bodies) remains constant. [No marks for "momentum of a body"]. (2)

2.2 Σp before collision = Σp after collision (method)
$m_1v_{i1} + m_2v_{i2} = (m_1 + m_2)v_f$ Method can be implied.
$(1500 \times 20) + (1000 \times v) = (1500 + 1000)(6)$
$v = -15$ m.s^{-1} [Ignore the sign] (4)
(-1 no unit OR incorrect unit)

2.3 **Before collision**
$E_k = ½mv^2$
$= (½ \times 1\,500 \times 20^2) + (½ \times 1\,000 \times 15^2)$ c.o.e. from 2.2
$= 300\,000 + 112\,500$
$=$ **412 500 (J)**
After collision
$E_k = ½mv^2$
$= ½ \times 2\,500 \times 6^2$
= 45 000 (J) Ignore the SI units here.
Collision is **INELASTIC** since kinetic energy has been lost. (6)

Note: $\Sigma E_{k\ before} = \Sigma E_{k\ after}$ (-1 mark)

INELASTIC because they stuck together (No calculation shown) 1 out of 6 marks

2.4 P = F.v
38 000 = F.20(conversion from kW to W; substitution)
F = 1 900 N (-1 no unit OR incorrect unit) (4)

OR
P = F.v
38 = F.20(substitutions)
F = 1,9 kN (-1 no unit OR incorrect unit)

2.5 **The relative velocity** of an object is the velocity as defined by a given observer **OR** the vector difference in the velocities of two objects. (2)

2.6 $v_{BA} = 20 - (-15) =$ **35 m.s^{-1} towards A (or to the left)**
(c.o.e. from Question 2.2)
OR $v_{BA} = v_{BG} + v_{GB}$
$= -15 + (-20)$
$= -35$m.s^{-1} **[Also accept – 35 m.s^{-1} to the right]** (2)
(-1 no unit OR incorrect unit)

2.7 **Impulse** can be defined as the product of the net forceacting on a body and the time (for which it acts). **OR Impulse** is the net force times time **OR Impulse** is the (instantaneous) change in momentum. (2)
Note: Net force acting over time is incorrect (It implies division of net force by time)

2.8 2.8.1 Both cars experience the **same impulse**. (Neither) (1)

2.8.2 **Method 1**
Both cars experience the **same size force** (Newton's 3rd Law) for the **same time** period.
Impulse = $F_{net}.\ \Delta t$

Method 2
Impulse = $\Delta p = m\Delta v$
Car A $\Delta p = 1500(6 - 20) = -21\ 000$ kg.m.s^{-1}
Car B $\Delta p = 1\ 000(6 - (-15)) = 21\ 000$ kg.m.s^{-1} (3)

Method 3
Impulse = Δp
Σp is constant **OR** reference to the law of conservation of momentum
$\therefore \Delta p_A = -\Delta p_B$ OR $|\Delta p_A| = |\Delta p_B|$

2.9 2.9.1 **Driver B**
Formula

$F_{net} = \frac{m(v_f - v_i)}{\Delta t}$ **OR** $F_{net} = \frac{m\Delta v}{\Delta t}$ **OR** $F_{net} = m.a$; $a = \frac{\Delta v}{\Delta t}$ OR $F_{net}.\Delta t = m\Delta v$

The driver of car B undergoes a **greater change in velocity** () OR a greater acceleration () therefore experiences a **greater force** as **mass and Δt are the same for both drivers**.
Car A $\Delta v = (6 - 20) = -14$ m.s^{-1}
Car B $\Delta v = (6 - (-15)) = 21$ m.s^{-1} ()
() **ONE** of these only (4)

2.9.2 Air bags **increase the time** over which momentum changes therefore **decreasing the force** since $F_{net} = \frac{m\Delta v}{\Delta t}$; $F_{net} \alpha \frac{1}{\Delta t}$ (3)
OR
Newton's 1st Law Airbags stop the body from continuing its forward motion until it hits the steering wheel. [1 mark only]
OR
Newton's 2nd Law: When acceleration decreases, the net force also decreases. The airbag increases the time taken for the body to stop.

2.10 2.10.1 **Method 1**

$\Delta x = \frac{(v_i + v_f)}{2}.\Delta t$

$9 = \frac{(6 + 0)}{2}.\Delta t$

Δt = 3 s(-1 no unit OR incorrect unit)

Alternative

$v_f^2 = v_i^2 + 2a\Delta x$

$0^2 = 6^2 + 2a(9)$

$a = -2 m.s^{-2}$ (-1 no unit OR incorrect unit)

Method 2

$v_f = v_i + a\Delta t$

$0 = 6 - 2\Delta t$

$\Delta t = 3 s$ (-1 no unit OR incorrect unit)

Method 3

$\Delta x = v_i \Delta t + \frac{1}{2} a \Delta t^2$

$9 = 6\Delta t + \frac{1}{2}(-2)\Delta t^2$

$\Delta t = 3 s$ (-1 no unit OR incorrect unit) (4)

2.10.2 **Method 1** (Impulse)

$F_{net} = \frac{m(v_f - v_i)}{\Delta t}$

$= \frac{2\ 500 \quad (0 - 6)}{3}$ Allow (6) and (6 – 0) as Δv (c.o.e. from 2.10.1)

$= -5\ 000$ N

Frictional force = 5 000 N backwards (or to the left)
(-1 no unit OR incorrect unit)

Method 2 (Newton's 2nd Law)
Both formulae correct

$v_f = v_i + a\Delta t$ **OR** $v_f^2 = v_i^2 + 2a\Delta x$ **OR** $\Delta x = v_i\Delta t + \frac{1}{2} a\Delta t^2$

OR c.o.e. from 2.10.1

$0 = 6 + a(3)$ | $0^2 = 6^2 + 2a(9)$ | $9 = 6(3) + \frac{1}{2} a.3^2$

$a = -2 m.s^{-2}$ | $a = -2 m.s^{-2}$ | $a = -2 m.s^{-2}$

$F_{net} = ma$
$= 2\ 500 \times (-)2$ [Ignore sign]
$= (-)5\ 000$ N

Frictional force = 5 000 N backwards (or to the left)
(-1 no unit OR incorrect unit)

Method 3 (Work-Energy Theorem) Method(can be implied)

$\Delta E_k = F_{net}.\Delta x$ **OR** $\Delta E_k = F_{net}.\Delta x.\cos\theta$

$(0 -)45\ 000 = F_{net} \times 9$ c.o.e. from 2.3 $(0 -)45\ 000 = F_{net} \times 9 \times (-1)$

$F_{net} = 5\ 000$ N Ignore sign $F_{net} = 5\ 000$ N

Frictional force = 5 000 N backwards (or to the left) (6)
(-1 no unit OR incorrect unit)

QUESTION 3 PROJECTILE MOTION

3.1 **Horizontal**

$v_{ix} = v\cos 60$

$t = \dfrac{27}{v\cos 60}$ Method of getting t

(distance = average velocity x time at constant velocity)

$t = \dfrac{54}{v}$ OR $v = \dfrac{54}{t}$

Vertical **Marks for substitution**

$\Delta y = v_{iy}\Delta t + \frac{1}{2}a\Delta t^2$ $\Delta y = 1,77$ m

$1,77 = (v\sin 60).\dfrac{54}{v} + \dfrac{1}{2}(-10).\dfrac{54^2}{v^2}$ $v_{iy} = v\sin 60$

$1,77 = 46,765 - \dfrac{14\ 580}{v^2}$ $\Delta t = \dfrac{54}{v}$ OR $v = \dfrac{54}{t}$

v = 18 m.s^{-1} (-1 no unit OR incorrect unit)

Note 1: Check that acceleration and velocity have opposite signs.
Note 2: Using g = 9,8 m.s^{-2} v = 17,82 m.s^{-1}

3.2 3.2.1

Time (s)	Horizontal distance (m)	Vertical distance below start (m)
0,0	0,00	0,00
0,2	0,24	0,06
0,4	0,48	**0,24**
0,6	0,72	0,54
0,8	0,96	0,96
1,0	**1,2**	1,50

(4)

3.2.2 There is a constant increase in distance/position (of 0,24 m) per (0,2 s) time interval. OR travelled the same distance in each time interval OR constant displacement per unit time. (2)

3.2.3 $v = \dfrac{s}{t} = \dfrac{0,24}{0,2}$ **= 1,2 m.s^{-1}** (-1 no unit OR incorrect unit) (3)

Any pair of corresponding values can be used to obtain the same result.

3.2.4

Time interval (s)	0 – 0,2	0,2 – 0,4	0,4 – 0,6	0,6 – 0,8	0,8 – 1,0
Vertical distance (m)	**0,06**	**0,18** c.o.e.	**0,30** c.o.e.	**0,42**	**0,54**

(5)

3.2.5 **Method 1**

There is a constant increase in displacement (OR change in position OR in vertical distance OR increase of 0,12 m) between (consecutive) time intervals, therefore, a constant increase in velocity.

No marks for: a constant increase in position.

Method 2

There is a constant increase in the (average) velocity of 0,6 $m.s^{-1}$ () between (consecutive) time intervals indicating a constant acceleration.

OR When data is given:

Time interval (s)	0 – 0,2	0,2 – 0,4	0,4 – 0,6	0,6 – 0,8	0,8 – 1,0
Average velocity ($m.s^{-1}$)	0,06 ÷ 0,2 = **0,3**	0,18 ÷ 0,2 = **0,9**	0,30 ÷ 0,2 = **1,5**	0,42 ÷ 0,2 = **2,1**	0,54 ÷ 0,2 = **2,7**

() Finding average velocity for each time interval (method)

() Find increase in average velocity (4)

3.2.6 **Method 1**

$$\Delta y = v_i\Delta t + \frac{1}{2}a\Delta t^2 \quad (v_i = 0)$$

a = 3 m.s^{-2} (-1 no unit OR incorrect unit)

The values used for Δt and Δy must be the correct 'pair' of data as given in the adjacent table.

Δt (s)	Δy (m)
0,2	0,06
0,4	0,24
0,6	0,54
0,8	0,96
1,0	1,50

Method 2

The average velocity for a time interval is equal to the instantaneous velocity at the middle of the time interval.

$v_f = v_i + a\Delta t$

a = 3 m.s^{-2}(-1 no unit OR incorrect unit)

The values used for Δt, v_i and v_f must be the correct 'combination' of data as given in the adjacent table.

Δt (s)	v ($m.s^{-1}$)
0,1	0,3
0,3	0,9
0,5	1,5
0,7	2,1
0,9	2,7

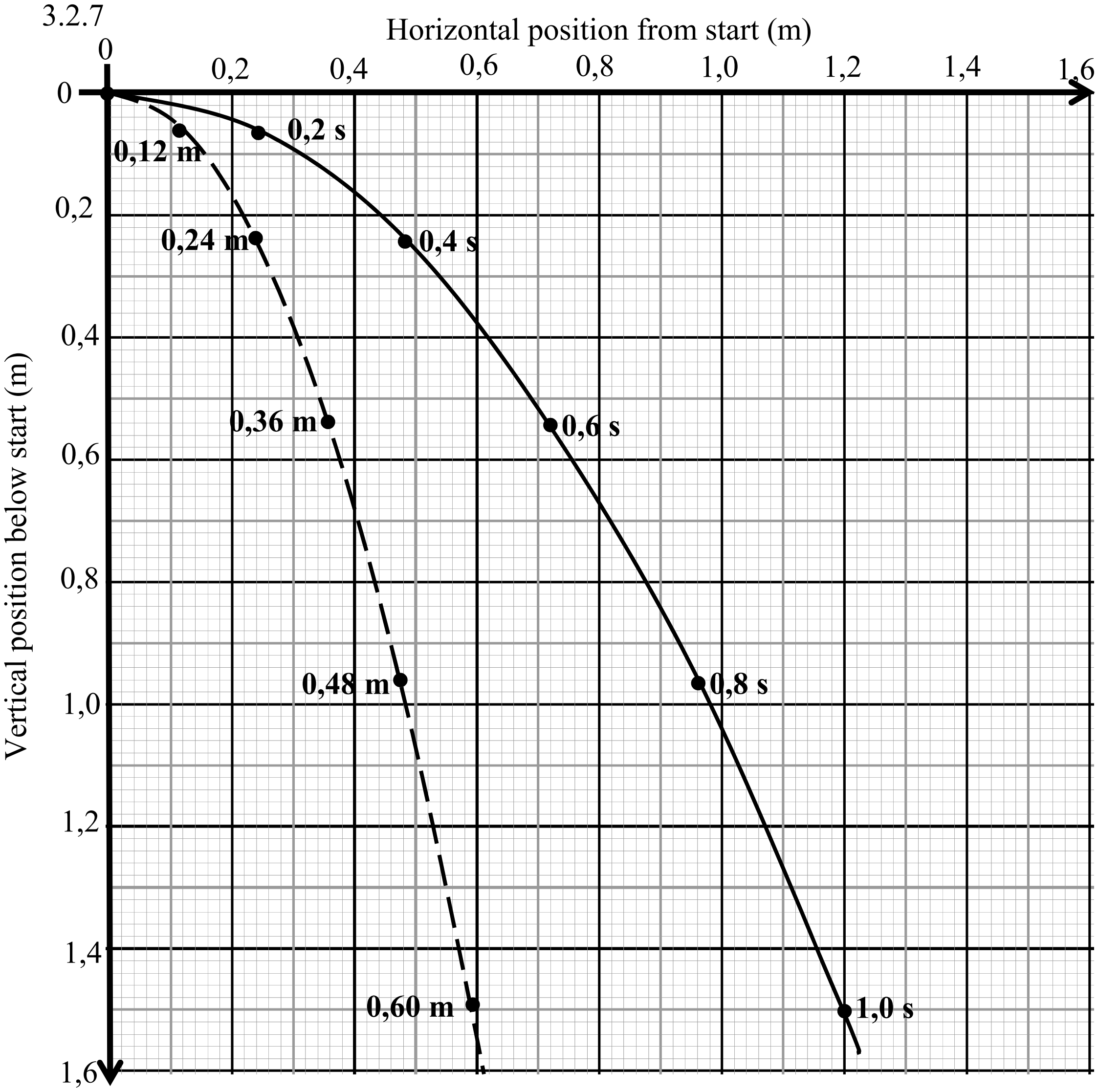
Method 3

$$a = \frac{\Delta v}{\Delta t}$$

$$= \frac{0,6}{0,2} \quad \text{c.o.e. from 3.2.5}$$

= 3 m.s^{-2} (-1 no unit OR incorrect unit) (4)

3.2.7



Allocate part marks as follows:

- Curve to left of original
- Points at correct vertical position
- ONE point at correct horizontal position
- ALL points at correct horizontal position (4)

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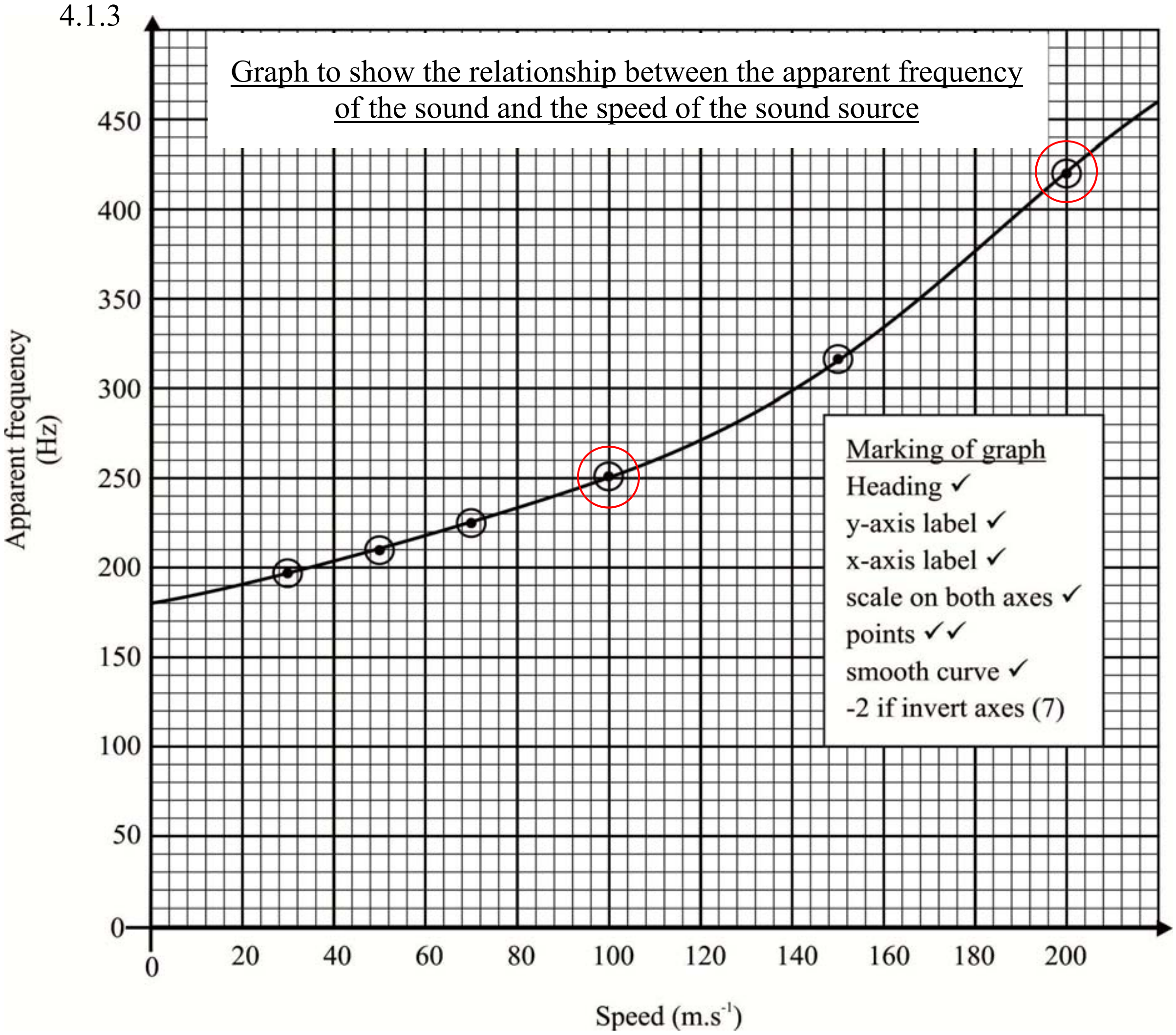
QUESTION 4 DOPPLER EFFECT

4.1 4.1.1 Speed This is the **independent variable OR** it is manipulated by the person conducting the experiment. **OR** It does not depend on the frequency. (2)

4.1.2 The **frequency of the source**; the **speed of sound** (which depends on **temperature** and wind) which must be constant (any <u>one</u>)OR Observer must be stationary–with explanation of how this would affect the outcome.
A change in one of these variables will

- change the value of the dependent variable (apparent frequency)
  OR
- change the outcome of the experiment
  OR
- result in an unfair test. (3)

4.1.3



Plotting points accurately: Check the two points which are circled, then the general shape of the graph.
The candidate's graph must use more than half of the graph paper supplied.
NB: Before deducting marks for inverting the axes, check back to 4.1.1 and mark as c.o.e. if applicable.
NB: A non-linear scale on either axis is awarded a maximum of 3 marks.

4.1.4 ± 140 $m.s^{-1}$ (1 little block leeway) (-1 no units) (2)

4.1.5 ± 180 Hz (read off y-intercept)(1 little block leeway) (-1 no units) (2)

4.1.6 $f_0 = \frac{v}{v - v_s}.f_s$ Formula must be $(v - v_s)$

$252 = \frac{v}{v - 100}.180$ c.o.e. from 4.1.5

v = 350 $m.s^{-1}$(-1 no unit OR incorrect unit) (4)

If a different pair of data is used, maximum of 3 out of 4 marks.

4.2 4.2.1
- The transmitter emits a (continuous (ultrasonic sound)) wave which is reflected off the moving blood cells back to the receiver.
- Since the blood cells are moving (away from the receiver) the reflected waves have a **lower (OR change in) frequency** (longer wavelength) than the transmitted waves.
- This shift in frequency can be used (in the Doppler equation) to calculate the speed of the blood cells, which act as the source of the reflected wave. OR The Doppler effect can be used to calculate the speed of blood flow. (4)

4.2.2 speed traps, speed of cricket balls, monitoring of foetal heart beats, motion sensors e.g. in burglar alarms, Doppler radar for weather.(One only) (1)
NB Not ultrasound (imaging).

[25]

QUESTION 5 AMBULANCE

Do not penalise 5.1 or 5.2 if the answer is not given to two decimal places.

5.1 $I = \frac{V}{R}$ in any format e.g. V = IR

$= \frac{6}{(7{,}2+12)}$

I = 0,31 A (-1 no unit OR incorrect unit) (4)

5.2 c.o.e. for I = 0,31 A from 5.1

$P = I^2R$

$= 0{,}31^2 \times 7{,}2$

P = 0,69 W

(-1 no unit OR incorrect unit)

V = I.R

= 0,31 × 7,2 (c.o.e. for current from Question 5.1)

= 2,232 V

P = V.I

= 2,232 × 0,31

P = 0,69 W

$P = \frac{V^2}{R} = \frac{2{,}232^2}{7{,}2}$

P = 0,69 W (4)

5.3 V_{motor} = I.R

= 0,2 (conversion) × 12

= 2,4 V(-1 no unit OR incorrect unit) (3)

5.4 $I_{bulb} = \frac{V}{R}$

$= \frac{3{,}6}{7{,}2}$ (V_{bulb} = (6 – 2,4) = 3,6 V) c.o.e. from 5.3

$\mathbf{I_{bulb}}$ **= 0,5 A**(-1 no unit OR incorrect unit) (3)

5.5 $R_{total} = \frac{V}{I}$

$= \frac{6}{0{,}5}$ c.o.e. from 5.4

$\mathbf{R_{total}}$ **= 12 Ω**(-1 no unit OR incorrect unit) (3)

5.6 **Method 1**

$I_{siren} = (0,5 - 0,2) =$ **0,3 A** c.o.e. from 5.5

$R_{siren} = \frac{V}{I}$

$= \frac{2,4}{0,3}$ c.o.e. from 5.3 c.o.e. from 5.4

$\mathbf{R_{siren} = 8\ \Omega}$ (-1 no unit OR incorrect unit)

Method 2

$R_{parallel} = (12 - 7,2) = 4,8\ \Omega$c.o.e. from 5.5

OR $R_{parallel} = \frac{V}{I}$

$= \frac{2,4}{0,5}$ c.o.e. from 5.4

$= 4,8\ \Omega$(-1 no unit OR incorrect unit)

$4,8 = \frac{(R_x \times 12)}{(R_x + 12)}$ **OR** $\frac{1}{4,8} = \frac{1}{R_x} + \frac{1}{12}$

c.o.e. $R_{//}$ from 5.5

$\mathbf{R_{siren} = 8\ \Omega}$ (-1 no unit OR incorrect unit) (4)

5.7 5.7.1 Increase (1)

5.7.2 Decrease (1)

NB The answers to 5.8 and 5.9 must link POWER of the bulb to brightness, and to speed of the motor.

5.8 **Method 1**

The bulb receives **more current**than previously (0,5 A compared with 0,31 A) therefore a greater rate of transfer of energy (power) $P = I^2R$

Method 2

The **p.d. across the bulb has increased** (3,6 V compared with 2,23 V) therefore a greater rate of transfer of energy (power) $P = V^2/R$

Method 3

The bulb receives more current AND the p.d. across it is greater therefore a greater rate of transfer of energy (power) P = V.I () (2)

Only award formula mark in method 3 if ***both I and p.d****. are recognised as changing.*

5.9 **Method 1**

The motor receives **less current** than previously (0,2 A compared with 0,31 A) therefore less power, $P = I^2R$ *(R is constant)*

Method 2

The **p.d. across the motor has decreased** (2,4 V compared with 3,768 V) therefore less power, $P = V^2/R$ *(R is constant)*

Method 3

The motor receives **less current** AND the **p.d. across it is lower** therefore less power, P = V.I (2)

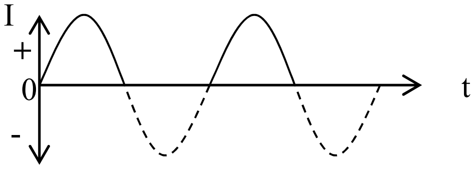
Only award formula mark in method 3 if ***both I and p.d****. are recognised as changing.* **[27]**

QUESTION 6 GENERATOR

6.1 Mechanical (kinetic) to electrical[Not: wind to light] (2)

6.2 There is **change in magnetic flux (linkage)** between the coils and the magnet as the magnet spins which induces an emf in the coil OR magnetic field (lines) cutting through conductor / coil. (2)

6.3 The wind generator produces an **alternating current.** The LED will only allow current to pass through in **one direction** (left to right) therefore it will only light up for every half revolution of the magnet (OR LED will only conduct current in forward bias OR half-wave rectification through the diode.)



The 'negative' current is blocked.

(4)

6.4 Greater **rate** of change of magnetic flux (linkage) therefore greater (induced) emf (therefore greater current).
OR emf = - N$\frac{\Delta\Phi}{\Delta t\Delta}$ (or equivalent statement of Faraday's Law) Magnet turns faster ∴ less time greater emf / current (4)

6.5 It can **spin faster** for less wind power, therefore, a greater induced emf.
OR Less inertia OR easier to start it spinning OR less energy lost OR more efficient

6.6
- More coils on solenoid
- Stronger magnet [Not: bigger magnet nor lighter magnet]
- Change shape/number/weight of blades to catch wind better OR reduce friction by adding bearings or using lubricant and <u>hence blades spin faster.</u>

(Any TWO suitable) (2)

6.7 6.7.1 Hydro-electric power; solar panels; tidal power; wave power, geothermal (Any TWO suitable) (NOT nuclear or any fossil fuels) (2)

6.7.2 No wind = no power (1)

6.7.3
- Uses large tracts of land (deforestation)
- Disrupts bird flight patterns
- Noisy
- Spoils the view of landscape (eye-sore), ugly
- Disturbs local climate
- Generators use rare earth metals for their magnets; materials used in generators have a carbon-footprint.

(Any TWO suitable) (4)

[23]

QUESTION 7 AUTOMATIC CAMERA

7.1 Photoelectric effect. (1)

7.2 7.2.1 no effect (1)

7.2.2 increase (1)

7.2.3
- With bright light **more photons** strike the metal surface per second.
- **One photon transfers its energy to one electron** which escapes; therefore **more electrons emitted per second**, therefore greater current (I = Q/t) OR rate of electron emission increases.
- **The energy of each photon is the same**; therefore the kinetic energy of the emitted electrons is constant. (4)

7.3 Increases (1)

7.4 Candidates must show at least ONE of the formulae given below with relevant application to get the formula mark.
- The higher the frequency the **higher the energy** (**per photon**) ($E = h.f$)
- The emitted electrons have **more kinetic energy** ($E_k = hf - W_f$)
- The speed of the electrons that are emitted increases ($E_k = \frac{1}{2} mv^2$) (3)

7.5 7.5.1 $f = \frac{v}{\lambda}$ OR $E_{light} = \frac{h.c}{\lambda}$ and $E = h.f$

$f = \frac{3 \times 10^8}{480 \times 10^{-9}}$ (conversion)

$\mathbf{f = 6,25 \times 10^{14}}$ **Hz** (-1 no unit OR incorrect unit) (4)

7.5.2 **Method 1** **OR** **Method 2**

Method 1:

$E_{light} = \frac{h.c}{\lambda}$

$= \frac{6,6 \times 10^{-34} \times 3 \times 10^8}{480 \times 10^{-9}}$ c.o.e. 7.5.1

$= 4,125 \times 10^{-19}$ (J)

Method 2:

$E = h.f$

$= 6,6 \times 10^{-34} \times 6,25 \times 10^{14}$ c.o.e 7.5

$= 4,125 \times 10^{-19}$ (J)

[Candidates may combine one of these methods in the following formula]

$E = W_f + \frac{1}{2} mv^2$

$\frac{1}{2} mv^2 = (4,125 \times 10^{-19} - 3,8 \times 10^{-19})$ ()

$\frac{1}{2} mv^2 = 3,25 \times 10^{-20}$ J ()

() *either/or gets 1 mark in total*

$\frac{1}{2} \times 9,1 \times 10^{-31} \times v^2 = 3,25 \times 10^{-20}$

$\mathbf{v = 2,67 \times 10^5\ m.s^{-1}}$ (-1 no unit OR incorrect unit) (7)

7.5.3 The frequency of the new light is **lower than the threshold frequency** of the metal.

OR The energy of the new light is **lower than the work function** of the metal. (2)

OR The wavelength of the new light is longer than the threshold wavelength of the metal. (2)

Not: Frequency is less than work function.

7.6 7.6.1 **Capacitance** is the ratio of the charge on one of the plates of a capacitor to the potential difference across the plates OR Capacitance is the ability to store charge OR Capacitance is charge per unit voltage. (2)

Note: Charge per unit volt [Only 1 mark]

7.6.2 $C = \frac{Q}{V}$

$Q = C \times V$

$= 220 \times 10^{-6}$ (conversion) $\times 360$

Q = 0,079 C (-1 no unit OR incorrect unit) (4)

[30]

Total: 200 marks

