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## MARKING MEMORANDUM

QUESTION 1
$1.1 \quad D \checkmark \checkmark$
$1.2 \mathrm{D} \checkmark \checkmark$
$1.3 \quad C \checkmark \checkmark$
1.4 A $\checkmark \checkmark$
$1.5 B \checkmark \checkmark$
$1.6 B \checkmark \checkmark$
1.7 A $\checkmark \checkmark$
1.8 C $\checkmark \checkmark$
$1.9 \mathrm{D} \checkmark \checkmark$
$1.10 C \checkmark \checkmark$

## QUESTION 2

2.1


## 1 mark per arrow and label

 subtract 1 mark for each of the following errors:- no dot shown
- T shown with its components (unless components in dashed lines)

2.2 When a resultant (net) force acts on an object, the object will accelerate in the direction of the force. This acceleration is directly proportional to the force $\checkmark$ and inversely proportional to the mass $\checkmark$ of the object. OR
The resultant/net force acting on an object is equal to the rate of change of momentum of the object $\checkmark \checkmark$ in the direction of the resultant/net force. (2 or 0)
$2.3 \quad f_{\mathrm{s}}^{\text {max }}=\mu_{s} F_{N}$
$120=(0,34) F_{N} \checkmark$
$F_{N}=352,9412 N$
Vertical forces; taking up as positive
$\vec{F}_{\text {net }, y}=0$
$\overrightarrow{\mathrm{T}}_{\mathrm{y}}+\overrightarrow{\mathrm{F}}_{\mathrm{N}}+\overrightarrow{\mathrm{F}}_{\mathrm{g}}=0 \checkmark$
$\mathrm{Ty}+\mathrm{F}_{\mathrm{N}}-\mathrm{mg}=0$
$\mathrm{Ty}+352,9412 \checkmark-(50)(9,8) \checkmark=0$
$\mathrm{Ty}=137,06 \mathrm{~N}$
2.4 Horizontal forces; taking left as positive
$\vec{F}_{\text {net }, x}=0$
$\vec{T}_{x}+\vec{f}_{\mathrm{s}}^{\text {max }}=0 \checkmark$
$T x-120=0$
$T x=120 \mathrm{~N}$
(B)


## (A) / (B):

$$
\begin{aligned}
\tan \theta & =\frac{137,06 \ldots}{120} \\
& =1,14215 \ldots \\
\theta & =48,80^{\circ}
\end{aligned}
$$

## Sub into (B)

OR $\quad$ Subst into (A)
$T \cos \left(48,8^{\circ}\right)=120$
$T=182,18 \mathrm{~N}$
$T \sin \left(48,8^{\circ}\right)=137,06$
$\mathrm{T}=182,16 \mathrm{~N}$
2.5.1 DECREASES $\checkmark$
2.5.2 From: $T_{y}=T \sin \theta$. The angle $(\theta)$ increases $\checkmark$, so the vertical component of the tensional force $\left(T_{y}\right)$ will increase $\checkmark$.
From: $F_{N}+T_{y}=F_{g}$
$\theta$ increases/ $\mathrm{T}_{\mathrm{y}}$ increases
The parcel will not push as hard into the table surface ${ }^{\checkmark}$ so the normal force will decrease in magnitude. (2)

QUESTION 3

$5 \%$ energy loss so this represents $95 \%$ of the energy after the bounce.

$$
\begin{aligned}
\therefore E_{\mathrm{k}, \text { before }} & =0,8644 \times \frac{100}{95} \checkmark \\
& =0,90989 \ldots \mathrm{~J} \\
& \approx 0,91 \mathrm{~J} \quad \checkmark
\end{aligned}
$$

3.3

$$
\begin{aligned}
\left(E_{P}+E_{K}\right)_{\text {TOP }} & =\left(E_{P}+E_{\text {Kı }}\right)_{\text {воттом }} \\
{\left[m g h+1 / 2(0,05)(3)^{2}\right]_{\text {top }} } & =(0+0,91) \quad \checkmark \text { (all subst) } \\
h & =0,685 /(0,05)(9,8) \\
& =1,398 \mathrm{~m}=(0,4 \mathrm{~m})
\end{aligned}
$$

OR
Work Energy Theorem

OR

$$
\begin{equation*}
W_{n c}=\Delta E_{p}+\Delta E_{k} \tag{3}
\end{equation*}
$$

3.4


## QUESTION 4

4.1 The total linear momentum $\checkmark$ of an isolated (closed) system remains constant $\checkmark$ (is conserved). OR In an isolated system $\checkmark$ The total linear momentum before collision equals the total linear moment after collision.

### 4.2 Linear momentum conservation:

Take "towards Orion" as the positive direction:

$\left(3,6 \times 10^{19}\right)(5) \checkmark=m_{\mathrm{A}}(8) \checkmark+\left(3,6 \times 10^{19}-m A\right) \checkmark(-2)^{\checkmark}$ $10 \mathrm{~m}_{\mathrm{A}}=1,8 \times 10^{20}+7,2 \times 10^{19}$ $m_{A}=2,52 \times 10^{19} \mathrm{~kg}$

Take "towards Orion" as the positive direction:

$$
\left.\begin{array}{rl}
\sum \vec{p}_{\mathrm{i}} & =\sum \vec{p}_{\mathrm{f}} \\
M \vec{v}_{\mathrm{i}} & =m_{\mathrm{A}} \vec{v}_{\mathrm{A}, \mathrm{f}}+m_{\mathrm{B}} \vec{v}_{\mathrm{B}, \mathrm{f}}
\end{array}\right]
$$

Mass conservation:

$$
\begin{align*}
& m_{\mathrm{A}}+m_{\mathrm{B}}=M \\
& \quad m_{\mathrm{A}}+m_{\mathrm{B}}=3,6 \times 10^{19} \mathrm{~kg} \checkmark \tag{B}
\end{align*}
$$

sub (A) into (B):

$$
\begin{aligned}
2,25 \times 10^{19}+0,25 m_{\mathrm{B}}+m_{\mathrm{B}} & =3,6 \times 10^{19} \mathrm{~kg} \\
1,25 m_{\mathrm{B}} & =1,35 \times 10^{19} \mathrm{~kg} \\
m_{\mathrm{B}} & =1,08 \times 10^{19} \mathrm{~kg}
\end{aligned}
$$

sub $m_{B}$ into ( $B$ ):

$$
\begin{aligned}
m_{\mathrm{A}}+1,08 \times 10^{19} & =3,60 \times 10^{19} \\
m_{A} & =2,52 \times 10^{19} \mathrm{~kg}
\end{aligned}
$$

Take "towards Orion" as the positive

$$
\begin{align*}
& \text { direction: } \\
& \left.\begin{array}{c}
\sum \vec{p}_{\mathrm{i}}=\sum \vec{p}_{\mathrm{f}} \\
M \vec{v}_{\mathrm{i}}=m_{\mathrm{A}} \vec{v}_{\mathrm{A}, \mathrm{f}}+m_{\mathrm{B}} \vec{v}_{\mathrm{B}, \mathrm{f}}
\end{array}\right] \\
& \begin{array}{c}
\left(3,6 \times 10^{19}\right)(5)^{\checkmark} \\
=m_{\mathrm{A}}(8)+m_{\mathrm{B}}(-2)^{\checkmark} \\
1,8 \times 10^{20}+2 m_{\mathrm{B}}=8 m_{\mathrm{A}} \\
\mathrm{~m}_{\mathrm{B}}=4 \mathrm{~m}_{\mathrm{A}}-9 \times 10^{19}
\end{array}
\end{align*}
$$

## Mass conservation:

$m_{\mathrm{A}}+m_{\mathrm{B}}=M$
$m_{\mathrm{A}}+m_{\mathrm{B}}=3,6 \times 10^{19} \mathrm{~kg}$
sub (A) into (B):
$m_{A}+4 m_{A}-9 \times 10^{19}=3,6 \times 10^{19}$

$$
\begin{aligned}
5 \mathrm{~m}_{\mathrm{A}} & =3,6 \times 10^{19}+9 \times 10^{19} \\
\mathrm{~m}_{\mathrm{A}} & =2,52 \times 10^{19} \mathrm{~kg}
\end{aligned}
$$

4.3 Take "towards Orion" as the positive direction:

$$
\begin{align*}
\vec{F}_{\text {net }} \Delta t & =\Delta \vec{p} \quad \checkmark \\
& =m\left(\vec{v}_{\mathrm{f}}-\vec{v}_{\mathrm{i}}\right) \\
& =\left(2,52 \times 10^{19}\right)(8-5) \checkmark \\
& =7,56 \times 10^{19} \mathrm{~N} \cdot \mathrm{~s} / \mathrm{kg} \cdot \mathrm{~m} \cdot \mathrm{~s}^{-1} \text { towards Orion } \checkmark \quad \text { (magnitude + direction) } \tag{3}
\end{align*}
$$

4.4

$$
\begin{aligned}
F_{g} & =\frac{G m_{\mathrm{A}} m_{\mathrm{B}}}{r^{2}} \checkmark \\
& =\frac{\left(6,67 \times 10^{-11}\right)\left(2,52 \times 10^{19}\right)\left(1,08 \times 10^{19}\right) \checkmark}{\left(150 \times 10^{3}\right)^{2} \checkmark} \\
& =8,07 \times 10^{17} \mathrm{~N}
\end{aligned}
$$

## QUESTION 5

5.1 The net (total) work done on an object $\checkmark$ is equal to the change in the object's kinetic energy. $\checkmark \mathbf{O R}$ The work done on an object by a net (resultant) force $\checkmark$ is equal to the change in the object's kinetic energy.
5.2 $W_{\mathrm{g}}=F_{\mathrm{g}} \Delta y \cos \theta \checkmark$
$=m g \Delta y \cos \theta$
$=(75)(9,8)(2,4-1,6) \checkmark \cos 0^{\circ} \checkmark$
$=588 \mathrm{~J} \checkmark$
OR
work due to a conservative forces is equal to negative change in potential energy associated with that conservative force:

```
\(W_{\mathrm{c}}=-\Delta E_{\mathrm{p}}\)
\(W_{\mathrm{g}}=-m g\left(h_{\mathrm{f}}-h_{\mathrm{i}}\right)^{\checkmark}\)
    \(=-(75)(9,8) \checkmark(1,6-2,4) \checkmark\)
\(=588 \mathrm{~J} \checkmark\)
```

5.3


OR

$$
\begin{aligned}
W_{\mathrm{nc}} & =\Delta E_{\mathrm{p}}+\Delta E_{\mathrm{k}} \\
W_{f} & \left.=m g\left(h_{\mathrm{f}}-h_{\mathrm{i}}\right)+\frac{1}{2} m\left(v_{\mathrm{f}}^{2}-v_{\mathrm{I}}^{2}\right) \quad\right] \checkmark \\
& =(75)(9,8) \checkmark((1,6-2,4)) \checkmark+\frac{1}{2}(75)\left(\left(3,75^{2} \checkmark-0^{2}\right)\right) \checkmark \\
& =-60,66 \mathrm{~J} \quad \checkmark
\end{aligned}
$$

### 5.4.1 REMAINS THE SAME

5.4.2 The gravitational force is conservative (non-contact) force $\downarrow$, so the work done by the gravitational force will not depend on the path taken. $\checkmark$ The starting and ending points are the same. Therefore the work done by the gravitational force will remain the same.

## QUESTION 6

6.1.1 The apparent change in frequency in sound heard due to the relative motion between listener and/or source. $\checkmark \checkmark$
6.1.2

$$
\begin{gather*}
f_{L}=\left(\frac{v \pm v_{L}}{v \pm v_{S}}\right) f_{S} \\
\therefore 0,93 \mathrm{xf}_{\mathrm{S}} \checkmark=\left(\frac{335-0}{335+\mathrm{v}_{\mathrm{S}}}\right) \mathrm{f}_{\mathrm{S}} \\
\therefore 0,93\left(335+\mathrm{v}_{\mathrm{S}}\right)=335 \\
\therefore 0,93 \mathrm{v}_{\mathrm{S}}=335-0,93 \times 335 \\
\therefore \mathrm{v}_{\mathrm{S}}=\frac{0,07 \times 335}{0,93}=25,22 \mathrm{~m} \cdot \mathrm{~s}^{-1} \tag{4}
\end{gather*}
$$

6.2.1 Absorption (line spectrum) $\checkmark$
6.2.2 Red-shift $\checkmark$
6.2.3 Away from $\checkmark$

## QUESTION 7

7.1 The force of attraction or repulsion between two charges is directly proportional to the product of their charges $\checkmark$ and inversely proportional to the square of the distance between them/their centres.
$7.2 \quad \mathrm{~F}_{\mathrm{JonK}}=\frac{\mathrm{kQ}_{\mathrm{J}}^{\mathrm{g}} \mathrm{Q}_{\mathrm{K}}}{\mathrm{r}^{2}}$

$$
=\frac{9 \times 10^{9} \times 4 \times 10^{-6} \times 2 \times 10^{-6}}{\left(0,05 y^{2}\right.}
$$

$$
\begin{equation*}
=28,8 \mathrm{~N} \quad+\mathrm{ve} \tag{4}
\end{equation*}
$$

7.4 MAGNITUDE:

$$
\begin{aligned}
& \mathrm{F}_{\mathrm{R}}^{2}=\left(\mathrm{F}_{\mathrm{JonK}}\right)^{2}+\left(\mathrm{F}_{\mathrm{LonK}}\right)^{2} \\
& \begin{aligned}
\therefore \mathrm{F}_{\mathrm{R}} & =\sqrt{28,8^{2}+\left(\frac{1}{2} \times 28,8\right)^{2}} \\
& =32,20 \mathrm{~N}
\end{aligned}
\end{aligned}
$$

DIRECTION
$\tan \alpha=2$,
$\therefore \alpha=63,43^{\circ} \quad \checkmark$ Angle (show tan or other method)/BEARING 206,57 ${ }^{\circ}$
7.5 The electric field at a point is the electrostatic force experienced per unit positive charge $\checkmark$ placed at that point. $\checkmark$

## QUESTION 8

8.1 emf $\checkmark$
8.2 Load voltage OR external voltage OR terminal voltage
8.3 $V=I R$
$\therefore \mathrm{r}=\frac{\mathrm{V}_{\text {int }}}{\mathrm{I}}=\frac{0,9}{4,5}$

$$
\begin{equation*}
=0,2 \Omega \tag{3}
\end{equation*}
$$

$8.43 \Omega$
same $V \checkmark$ over each resistor and $\underline{\text { is inversely proportional to } R}$
$8.5 \quad \frac{1}{\mathrm{R}_{\mathrm{P}}}=\frac{1}{R 1}+\frac{1}{R 2}+\frac{1}{\mathrm{R} 3} \checkmark$

$$
=\frac{1}{4}+\frac{1}{3}+\frac{1}{4} \quad \checkmark=\frac{3+4+3}{12}=\frac{10}{12}
$$

$\therefore \mathrm{R}_{\mathrm{P}}=\frac{12}{10}=1,2 \Omega$
$\mathrm{R}_{\text {TOTAL }}=\frac{\varepsilon}{\mathrm{I}}=\frac{18}{4,5} \downarrow /=4 \Omega$
$\mathrm{R}_{\text {TOTAL }}=\mathrm{R}+\mathrm{R}_{\mathrm{P}}+\mathrm{r}$
$\therefore 4=\mathrm{R}+1,2+0,2$
$\therefore \mathrm{R}=2,6 \Omega$
8.6 Temperature $\checkmark$

$$
\begin{align*}
\mathrm{V}_{\mathrm{P}} & =\mathrm{I}_{\mathrm{P}} \mathrm{R}_{\mathrm{P}} \\
& =(4,5)(1,2) \quad \checkmark \quad 18-(0,9+5,4) \\
& =5,4 \mathrm{~V} \quad \checkmark \\
\mathrm{R} & =\mathrm{V} / \mathrm{I}=11,7 / 4,5=2,6 \Omega \quad \checkmark
\end{align*}
$$

8.7 $\quad R_{P}$ increases when $S_{2}$ is opened
so $\mathrm{R}_{\text {cir }}$ increases
so $I_{\text {cir }} /$ current strength through ammeter decreases
so $V_{\text {int }}(=\mid r)$ decreases ( $r$ constant)
so $\mathrm{V}_{\text {ext }}$ increases $\left(\mathrm{V}_{\text {ext }}=\varepsilon-\mathrm{V}_{\text {int }}\right)$

## QUESTION 9

$9.10,10$ s $\checkmark$
$9.2 \quad V_{\mathrm{rms}}=\frac{V_{\text {max }}}{\sqrt{2}}$

$$
=\frac{84,8}{\sqrt{2}}
$$

$$
\begin{equation*}
=60 \mathrm{~V} \tag{2}
\end{equation*}
$$

9.3.1 $\quad P_{\mathrm{avg}}=V_{\mathrm{rms}}{ }^{2}$
$\therefore 40=\frac{100^{2}}{R}$
$\therefore R=250 \Omega$
9.3.2 TOO DIM $\checkmark$
$\mathrm{V}_{\text {rms }}$ for $\mathrm{bulb}=100 \mathrm{~V}$
BUT $\quad V_{r m s}$ of generator -60 V .
9.4


## QUESTION 10

10.1 Planck's constant
10.2 Threshold frequency $\left(f_{0}\right)$ is the minimum frequency of light $\checkmark$ needed to emit (eject) electrons $\checkmark$ from the surface of a certain metal / material.
10.3

$$
\begin{aligned}
W_{0} & =h f_{0} \checkmark \\
& =\left(6,63 \times 10^{-34}\right)\left(1,4 \times 10^{15}\right)^{\checkmark} \\
& =9,282 \times 10^{-19} \mathrm{~J}
\end{aligned}
$$

10.4.1 The greater brightness would:

- increase the number $\checkmark$ of photoelectrons
10.4.2 - but would have no effect on their kinetic energies / Remain the same $\checkmark$
10.5

$$
\begin{aligned}
E_{\mathrm{k}, \max , \mathrm{E}} & =\frac{1}{2} m_{\mathrm{e}} v_{\max , \mathrm{E}}{ }^{2} \checkmark \\
2,4 \times 10^{-18} \checkmark & =\frac{1}{2}\left(9,11 \times 10^{-31}\right) \checkmark v_{\max , \mathrm{E}}^{2} \\
v_{\max , \mathrm{E}} & =2,3 \times 10^{6} \mathrm{~m} \cdot \mathrm{~s}^{-1} \quad \checkmark
\end{aligned}
$$

```
                    \(E=W_{o}+E_{k}\)
    \(1 / 2 m v^{2}=h f \quad W\)
\(1 / 2\left(9,11 \times 10^{-31}\right) v^{2} \checkmark=\left(6,63 \times 10^{-34}\right)\left(5 \times 10^{15}\right)-\left(9,282 \times 10^{-19}\right) \checkmark\)
\(v=2,29 \times 10^{6} \mathrm{~m} \cdot \mathrm{~s}^{-1}\)
```

OR
Learners can calc the gradient of the graph which $=6,67 \times 10^{-34}$ and then use above method.

