# Grading Standards <br> Physics 3204 <br> June 2009 

## Pre-Marking Appraisal

The exam rigidly adhered to the examination table of specifications.

## Post Marking Report

## a) Marking Standards and Consistency

Marker reliability was checked by obtaining a random sample of 50 examinations. These examinations were scored on separate back flaps with no physical markings on the original examinations and were held by the Chief Marker for recirculation throughout the marking period. These papers were corrected by the marking board again, and the initial and subsequent marks were compared. Any discrepancies in marking were reviewed and discussed with individual markers. Each marker also made on-going notes regarding partial marks and scoring for their particular question. Whenever a non-common error occurred, it was scored by consensus of the board and made note of, for scoring consistency.
b) Summary

While the overall performance in the Physics 3204 examination was slightly down from June 2008 to June 2009, it was still the second highest provincial score in the past five years. Some of the constructed response section of the exam was poorly answered with numerous students leaving items completely blank. This mostly occurred in items from Unit 2: Fields (Magnetism, Electromagnetism, \& Electromagnetic Induction).

Teachers should encourage students to read questions carefully and critically. Students must be vigilant when reading questions. Very often errors occur because students fail to read the entire question. If they read the complete question or read it several times, then they are less likely to misinterpret the item and are more likely to perform better.

There were several points that the marking board noted, specifically:

- Students appeared to have problems with basic definitions and physical principles. Students tended to treat definitions as "given" equations, therefore did not remember them or understand their concepts. The result was that students presented a random array of equations from the Data Sheet and used them incorrectly in the hopes of finding a solution.
- Students often provided incorrect units for their answers.
- Significant digits were often incorrect, leading to a wide spectrum of responses due to incorrect rounding throughout calculations.
- Many students wrote down values from the given information incorrectly.
- Many students were able to correctly select formulae and properly place values in them, but did not calculate correct answers. This error appears to be due to improper use of calculators and/or not understanding order of operations.


## c) Commentary on Responses

## Part I - Selected Response - Total Value: 50\%

Item \#46: Markers felt that it would benefit students to show the solution to this Level III item.

The graph provided shows the maximum kinetic energy of ejected electrons plotted against the frequency of the light shone on four different metals, A, B, C and D. What is the unknown metal if light of wavelength $1.87 \times 10^{-7} \mathrm{~m}$ shines on it and the maximum kinetic energy of the ejected electrons is 2.5 eV ?

i) $\quad E_{\gamma}=W_{0}+E_{K}, \quad$ where $E_{K}=(\mathrm{eV}) \cdot 1.6 \times 10^{-19}$
ii) $\frac{h \cdot c}{\lambda}=W_{0}+V Q$
$\frac{\left(6.626 \times 10^{-34}\right)\left(3 \times 10^{8}\right)}{1.87 \times 10^{-7}}=W_{0}+(2.5)\left(1.6 \times 10^{-19}\right)$
$1.06 \times 10^{-18}=W_{0}+4.0 \times 10^{-19}$
$W_{0}=6.6 \times 10^{-19} \mathrm{~J}$
iii) Relating the results to the graph, with no ejected electrons,
$E_{\gamma}=W_{0}$
$h \cdot f=W_{0}$
$\left(6.626 \times 10^{-34}\right) f=6.6 \times 10^{-19}$
iv) $f=1.0 \times 10^{15} \mathrm{~Hz} \Rightarrow$ metal "B"

## PART II - Constructed Responses: Total Value: 50\%

Value
4\% 51.(a) A ball is thrown from a 75.0 m high cliff, with an initial velocity of $82.0 \mathrm{~m} / \mathrm{s}$, at an angle of $53.0^{\circ}$ above the horizontal. Calculate the range of the ball when it hits the ground below.


## Method \#1:

1 mark $\left\{\begin{array}{l}\vec{v}_{2}^{2}=\vec{v}_{1}^{2}+2 \vec{a} \vec{d} \\ \vec{v}_{2}^{2}=(82.0 \sin 53)^{2}+2(-9.80)(-75.0) \\ \vec{v}_{2}=-75.4 \mathrm{~m} / \mathrm{s}\end{array}\right.$
1 mark $\left\{\begin{array}{l}t=\frac{\vec{v}_{2}-\vec{v}_{1}}{\vec{a}} \\ t=\frac{-75.4-82.0 \sin 53}{9.80}\end{array}\right.$ $t=14.4 \mathrm{~s}$

1 mark $\left\{\begin{array}{l}d_{x}=v_{x} \cdot t \\ d_{x}=(82.0 \cos 53.0) \cdot(12.8) \\ d_{x}=712 \mathrm{~m}\end{array}\right.$

1 mark \{ science and communication skills

## Method \#2:

1 mark $\left\{\begin{array}{l}\vec{d}=\vec{v}_{1} t+\frac{1}{2} \vec{a} t^{2} \\ -75.0=(82.0 \sin 53) t+\frac{1}{2}(-9.80) t^{2} \\ -75.0=(65.5) t+(-4.90) t^{2} \\ (4.90) t^{2}+(-65.5) t+(-75.0)=0\end{array}\right.$

1 mark $\left\{\begin{aligned} & x=\frac{-b \pm \sqrt{b^{2}-4 a c}}{2 a} \\ & t=\frac{-(-65.5) \pm \sqrt{(-65.5)^{2}-4(4.90)(-75.0)}}{2(4.90)} \\ & t=\frac{65.5 \pm \sqrt{5760}}{9.80} \\ & t=14.4 \mathrm{~s} \text { or }-1.06 \mathrm{~s}\end{aligned}\right.$

1 mark $\left\{\begin{array}{l}d_{x}=v_{x} \cdot t \\ d_{x}=(82.0 \cos 53.0) \cdot(14.4) \\ d_{x}=712 \mathrm{~m}\end{array}\right.$

1 mark \{ science and communication skills

## Common Errors:

- Many students misunderstood the principles of vectors and broke the time of flight into "up" and "down" segments of time. With the use of vectors, the determination of time could be calculated through one physical time segment.
- The displacement of 75.0 m [down] was not input into the equation as "- 75.0 ".
- Many students found the time for the maximum height, and doubled this value for the total time of flight, failing to consider that the projectile was displaced 75.0 m [down].
- Many students mistakenly used $d=\frac{v}{t}$ to calculate the range rather than $d=v \cdot t$.
- Although the quadratic formula was used by approximately $50 \%$ of the students, a majority could not work out the correct response.


## Value

$4 \% \quad 51$.(b) In the diagram provided, the coefficient of friction between the 2.0 kg mass and the horizontal surface is 0.15 , while the incline is frictionless.

i) Calculate the magnitude of the acceleration of the system.
0.5 marks $\left\{\begin{array}{l}\vec{F}=m \cdot \vec{a} \\ F_{A}-f=\left(m_{1}+m_{2}\right) \cdot \vec{a} \\ m_{2} g \sin \theta-\mu_{k} m_{1} g=\left(m_{1}+m_{2}\right) \cdot \vec{a}\end{array}\right.$
$\mathbf{1 . 5}$ marks $\left\{\begin{array}{l}(12.0)(9.80)(\sin 30.0)-(0.15)(2.0)(9.80)=(2.0+12.0) \cdot \vec{a} \\ 58.8-2.9=14.0 \vec{a} \\ 55.9=14.0 \vec{a}\end{array}\right.$
$\mathbf{0 . 5}$ marks $\left\{\begin{array}{l}a=3.99 \mathrm{~m} / \mathrm{s}^{2}\end{array}\right.$
ii) Calculate the magnitude of the tension in the connecting string.
0.5 marks $\left\{\begin{array}{l}\vec{F}=m \cdot \vec{a} \\ T-f=m_{1} \cdot \vec{a} \\ T-\mu_{k} m_{1} g=m_{1} \cdot \vec{a}\end{array}\right.$
$\mathbf{0 . 5}$ marks $\left\{\begin{array}{l}T-(0.15)(2.0)(9.80)=(2.0)(4.0) \\ T-2.94=8.0 \\ T=10.94\end{array}\right.$
0.5 marks $\quad\{\quad T=11 \mathrm{~N}$

## Common Errors:

## In 51(b) part i):

- Many students derived the wrong relationship to determine acceleration, failing to consider that the weight of $m_{2}$ only needed to be considered once (parallel component).

For example: $\quad F=m \cdot a$

$$
\begin{aligned}
& F_{\|}-F_{f}-F_{g}=m_{\text {total }} \cdot a \\
& m_{2} g \sin \theta-\mu m_{1} g-m_{2} g=m_{\text {total }} \cdot a
\end{aligned}
$$

- As well, many students used tension in attempting to calculate acceleration.

For example: $\quad F=m \cdot a$

$$
T-F_{\|}=m_{\text {total }} \cdot a
$$

## In 51(b) part ii):

- Many students inappropriately used the force of friction on the 2.0 kg mass when determining the tension using the 12.0 kg mass.

That is, $T+F_{f}=m_{2} \cdot a$ rather than $T+F_{\|}=m_{2} \cdot a$.

## Value

$3 \% \quad$ 51.(c) A 2.0 kg block is held at rest on a frictionless incline angled at $60.0^{\circ}$ by the horizontal force, F , shown below. Calculate the magnitude of F .


## Common Errors:

- Very few students were successful with this question. Most had the same incorrect response.

For example: $\quad F=F_{\|}-F$ (components are not in the same line)

$$
\begin{aligned}
& m \cdot a=F_{\|}-F \\
& m(0)=F_{\|}-F \\
& \therefore F_{\|}=F, \quad F_{\|}=m_{2} g \sin \theta=(2.0)(9.8)(\sin 60)=17 \mathrm{~N}
\end{aligned}
$$

since F is a horizontal component,

$$
\begin{aligned}
& F=17 \cos 60 \\
& F=8.5 \mathrm{~N}
\end{aligned}
$$

## Value

$3 \% \quad 51 .(\mathrm{d})$ A 0.40 kg stone is tied to a string and whirled around in a circle of radius 0.75 m with a constant speed of $5.0 \mathrm{~m} / \mathrm{s}$. In which situation is the string most likely to break? Explain.
i)


top of vertical circle

bottom of vertical circle
0.5 marks $\{\quad i)$ horizontal: $\quad T=F_{C}$

1 mark $\quad\{\quad i i)$ top vertical: $\quad T=F_{C}-F g$

1 mark $\left\{\right.$ iii) bottom vertical: $T=F_{C}+F g$
0.5 marks $\left\{\begin{array}{l}\text { The string will most likely break when the tension is the greatest. } \\ \text { That is at the bottom of the vertical circle. }\end{array}\right.$

## Common Errors:

- More than $1 / 3$ of students picked either diagram i (horizontal) or ii (top) as the answer, offering very little explanation. As a result, it was difficult to give partial marks for this question.
- Many students stated that "in a horizontal path", or "at the top of a vertical path", is when the tension is the least and, thus, is when the string is the most likely to break. It appears that students made a false assumption that "the least tension" in the string had the same meaning as "the least strength" in the string.


## Value

3\%
51.(e) A sign of mass M hangs from two cables as shown below. Calculate the mass of the sign if it is in static equilibrium.

0.5 marks $\left\{\begin{array}{l}T_{1 x}=T_{2 x} \\ T_{1} \cos \theta_{1}=T_{2} \cos \theta_{2}\end{array}\right.$
0.5 marks $\left\{\begin{array}{l}(75.0)(\cos 54.0)=T_{2}(\cos 32.0) \\ \mathbf{0 . 5} \text { marks }\end{array} \begin{array}{l}T_{2}=52.0 \mathrm{~N}\end{array}\right.$
0.5 marks $\left\{\begin{array}{l}T_{1 y}+T_{2 y}=F_{g} \\ T_{1} \sin \theta_{1}+T_{2} \sin \theta_{2}=m \cdot g\end{array}\right.$
0.5 marks $\quad\left\{\quad(75.0)(\sin 54.0)+T_{2}(\sin 32.0)=m(9.80)\right.$
0.5 marks $\quad\{\quad m=9.0 \mathrm{~kg}$

## Common Errors:

- Many students solved the problem assuming that $T_{1}=T_{2}$.
- Some students used $T_{2 x}$ instead of $T_{2 y}$.
- Some students felt that $\mathrm{F}_{\mathrm{g}}$ was the same as mass, leaving the answer in Newtons, and did not convert to kilograms.


## Value

$3 \% \quad$ 51.(f) A 12.0 kg uniform ladder that is 4.8 m long rests against a frictionless wall at an angle of $52^{\circ}$ to the ground as shown.

i) Calculate the force exerted on the ladder by the wall.
0.5 marks $\left\{\begin{array}{l}\tau_{c w}=\tau_{c c w} \\ \tau_{L}=\tau_{W} \\ F_{L} \times r_{L} \cos \theta=F_{W} \times r_{W} \sin \theta_{2}\end{array}\right.$
0.5 marks $\left\{[(12.0)(9.80)] \times\left[\left(\frac{4.8}{2}\right) \cos (52)\right]=\left[F_{W}\right] \times[(4.8) \sin (52)]\right.$
0.5 marks $\left\{\quad 170=\left[F_{W}\right] \times[3.8]\right.$
0.5 marks $\left\{\quad F_{W}=46 \mathrm{~N}\right.$
ii) Explain why the force of the wall on the ladder increases if a person stands on the ladder.
$\mathbf{0 . 5}$ marks $\left\{\begin{array}{l}\text { If the ladder is in rotational equilibrium, then } \tau_{\mathrm{cw}}=\tau_{\mathrm{ccw}} . \\ \text { Therefore, as a person ascends the ladder, the } \tau_{\mathrm{cw}} \text { increases, } \\ \text { and } \tau_{\mathrm{ccw}} \text { must increase in direct proportion to the } \tau_{\mathrm{cw}} .\end{array}\right.$
0.5 marks $\left\{\begin{array}{l}\text { Since the height of the ladder does not change, } \\ \text { the force of the wall on the ladder must increase. }\end{array}\right.$

## Common Errors:

- The most common error for this problem was not choosing the correct angle.
- For part ii, students responded by saying that the extra weight on the ladder puts greater force on the wall and in return the wall must push back with a greater force.


## Value

$3 \% \quad 52$. (a) Sphere A, which is positive, is held near a fixed positively charged sphere B as shown. Sphere A is then released and moves away from sphere B. Explain how and why the acceleration of sphere A changes as it moves away from sphere B.

$\mathbf{1}$ mark $\left\{\begin{array}{l}\text { The force between the two spheres follows an inverse square law } \\ \text { as the distance between them increases. }\end{array}\right.$
1 mark \{ Since the acceleration is directly proportional to the net force,
1 mark $\left\{\begin{array}{l}\text { the relative acceleration between the spheres will also follow an inverse } \\ \text { square law as the distance between the spheres increases. }\end{array}\right.$ For example, if the distance between the spheres increases $2 \times$, the acceleration will decrease $4 \times$.

## Common Errors:

- A large number of students did not comment on the inverse square law between distance and force.

Value
$3 \%$ 52.(b) Three charged objects are arranged as shown. Calculate the net electric force on object B due to the presence of objects A and C .


1 mark $\begin{cases}F_{A B}=\frac{k q_{A} q_{B}}{r_{A B}^{2}} & F_{C B}=\frac{k q_{C} q_{B}}{r_{C B}^{2}} \\ F_{A B}=\frac{\left(9.0 \times 10^{9}\right)\left(1.7 \times 10^{-6}\right)\left(-2.5 \times 10^{-6}\right)}{(0.15)^{2}} & F_{C B}=\frac{\left(9.0 \times 10^{9}\right)\left(-2.5 \times 10^{-6}\right)\left(4.2 \times 10^{-6}\right)}{(0.35)^{2}}\end{cases}$
$\mathbf{1}$ mark $\left\{\begin{array}{l}F_{A B}=-1.7 \mathrm{~N} \\ F_{A B} \text { attracts } 1.7 \mathrm{~N}[\text { Left }]\end{array}\right.$
$F_{C B}=-0.77 \mathrm{~N}$
$F_{C B}$ attracts $0.77 \mathrm{~N}[$ Right $]$

1 mark $\left\{\begin{aligned} \vec{F} & =\vec{F}_{A B}+\vec{F}_{C B} \\ \vec{F} & =-1.7 \mathrm{~N}+0.77 \mathrm{~N} \\ \vec{F} & =-0.9 \mathrm{~N} \\ \vec{F} & =0.9 \mathrm{~N}[\text { Left }]\end{aligned}\right.$

## Common Errors:

- This question was done reasonably well.
- Students had problems calculating the answer with their calculator even though the values were correctly substituted into each formula.
- Some students used the electric field strength formula instead of Coulomb's Law.
- Students did not state the direction.


## Value

5\% 52.(c) In the circuit shown:

i) calculate the total resistance.

$$
\left.\begin{array}{l}
\text { 0.5 marks }
\end{array}\left\{\begin{aligned}
& R_{2} \& R_{3} \text { are in parallel, } \therefore R_{p}=\left(R_{2}^{-1}+R_{3}^{-1}\right)^{-1} \\
& R_{p}=\left(8.0^{-1}+40.0^{-1}\right)^{-1} \\
& R_{p}=6.7 \Omega
\end{aligned}\right\} \begin{array}{ll}
R_{1} \& R_{p} \text { are in series, } \therefore \begin{array}{l} 
\\
\\
\mathbf{0 . 5} \text { marks }
\end{array} & R=R_{1}+R_{p} \\
R=5.0+6.7 \\
& R=11.7 \Omega
\end{array}\right]
$$

ii) calculate the voltage across resistor 2 .

1 mark
The total current leaving the source $=$ the current moving through the parallel arrangement.

$$
I_{p}=I=\frac{V}{R}=\frac{120}{11.7}=1.0 \times 10^{1} \mathrm{~A}
$$

1 mark
Since $R_{2}$ is part of the parallel arrangement, the voltage drop across $R_{2}=$ the parallel voltage drop. $V_{2}=V_{p}=I_{p} \cdot R_{p}=\left(1.0 \times 10^{1}\right)(6.7)=67$ Volts
iii) determine whether the fuse will blow.
$1 \mathrm{mark}\left\{\begin{array}{l}\text { Since } R_{3} \text { is in the parallel arrangement, } V_{3}=V_{p} . \\ I_{3}=\frac{V_{3}}{R_{3}}=\frac{67}{40.0}=1.7 \mathrm{~A}\end{array}\right.$

1 mark $\quad\left\{\quad\right.$ Since $I_{3}(1.7 \mathrm{~A})$ is less than $I_{\text {fuse }}(4.0 \mathrm{~A})$, the fuse will not blow.

## Common Errors:

## In 52(c) part i):

This question was answered fairly well by students.

- As stated earlier, many students had problems linking answers between parts i, ii, \& iii. This resulted in incorrect answers in parts ii \& iii.
- In the parallel arrangement, students calculated $R_{2}^{-1}+R_{3}^{-1}$, but did not find its reciprocal.
- Students did not show enough workings. Many created a chart without using the proper formula or required workings. There was little or no evidence of how values were calculated. Thus, incorrect answers could not receive part marks. Students must remember to show all required workings.
- Some students did not know the series and parallel characteristics (Kirchhoff's circuit rules). For example, series arrangements have a constant current with voltage sums, while parallel arrangements have a constant voltage with current sums.


## In 52(c) part ii):

- Many students found the current through the parallel branches, but when they found the voltage across $R_{2}$ they used the value of $R_{2}(8.0 \Omega)$ instead of the parallel voltage.


## In 52(c) part iii):

- Students did not explain why the fuse would blow. They found the current in the fuse and stated a conclusion (the fuse would blow or not blow) without making a comparison/connection.


## Value

$3 \% \quad 52 .(\mathrm{d})$ A 0.025 m long wire segment, XY , is positioned perpendicular to a 0.750 T magnetic field as shown. When a current is passed through this wire segment, it experiences a 0.20 N force upwards. Calculate the magnitude and give the direction of the current through the wire.

$\left.\begin{array}{ll}\mathbf{0 . 5} \text { marks } & \{F=B I \ell \sin \theta \\ \mathbf{0 . 5} \text { marks } & \{0.20=(0.750)(I)(0.025)(\sin 90) \\ \mathbf{0 . 5} \text { marks } & \{I=11 \mathrm{~A}\end{array}\right\} \begin{aligned} & \text { 0.5 marks }\end{aligned} \quad\left\{\begin{array}{l}\text { According to the "motor principal" LHR, } \\ \text { the current flows into the wire, from } \mathrm{X} \rightarrow \mathrm{Y} .\end{array}\right.$

1 mark $\{$ science and communication skills

## Common Errors:

This question was done reasonably well.

- Students stated the current flows into the wire from $\mathrm{Y} \rightarrow \mathrm{X}$. (In other words, they used Lenz's Law to determine the direction instead of the motor principle.)
- Others stated that the direction of the current was counterclockwise. They confused the direction of the current with the direction of the magnetic field.
- Many students did not use the correct number of significant digits.
- Other students used the correct formula but rearranged it incorrectly.
- Students did not use the calculator correctly.


## Value

$3 \% \quad 52 .(\mathrm{e})$ The diagrams provided show a metal rod, of mass $m$, suspended in a constant magnetic field by two identical wires. In diagram 1, there is no current in the wires, but in diagram 2, a current flows as shown. Compare the tension in the wires for diagram 2 to that for diagram 1. Explain your answer.

$\begin{array}{ll}\mathbf{1} \text { mark } & \left\{\begin{array}{l}\text { In diagram 1, each wire has } T=\frac{1}{2} m \cdot g .\end{array}\right. \\ \mathbf{1} \text { mark } & \left\{\begin{array}{l}\text { In diagram 2, each wire has } T=\frac{1}{2}(m \cdot g-B I l \sin \theta) .\end{array}\right. \\ \mathbf{1} \text { mark } & \left\{\begin{array}{l}\text { The lesser tension for diagram } 2 \text { is the result of a magnetic force being } \\ \text { exerted upwards on the wires according to LHR \#3 (the motor principle). }\end{array}\right.\end{array}$

## Common Errors:

This question was not answered well by students. A significant number of students did not even attempt this question.

- Many students did not compare the tension in the wires between diagram $1 \& 2$. Instead, they concentrated only on diagram 2.
- Approximately $1 / 3$ of the students thought the tension was greater in diagram 2.
- Other students believed that current and tension were one in the same. Students stated that diagram 1 had no tension because there was no current, and even neglected the weight of the rod. Students surmised that since diagram 2 had a current flowing through it, the tension in each string must be greater.
- Many students thought that the permanent magnetic field was going into the page rather than coming out of the page. Hence, they stated that the induced magnetic field was pushing the wire down the page. Consequently, they stated the tension in diagram 2 was greater.
- Others confused a current carrying conductor with a solenoid. Students believed that the current carrying conductor acted as a bar magnet.
- Many students ignored the current in the rod and concentrated on the current in the wires.
- Many students drew no distinction between magnetic fields and electric fields.
- A significant number of students believed that the current increased the mass of the rod and, therefore, increased the tension of the wires in diagram 2.
- A number of students tried to apply Lenz's Law.


## Value

$3 \% \quad 52 .(\mathrm{f})$ Calculate the magnitude and direction of the magnetic field strength at point P in the diagram provided.


According to LHR \#1 (current through a straight current-carrying wire), both magnetic fields will be moving out of the page at point "P". Therefore, both fields must be added together.
0.5 marks $\left\{\begin{array}{l}\vec{B}=\vec{B}_{1}+\vec{B}_{2} \\ \vec{B}=\frac{\mu_{0} I_{1}}{2 \pi r_{1}}+\frac{\mu_{0} I_{2}}{2 \pi r_{2}}\end{array}\right.$
1.5 marks $\left\{\begin{aligned} \vec{B} & =\frac{4 \not \subset \times 10^{-7}(0.30)}{2 \not t(0.020)}+\frac{4 \not \subset \times 10^{-7}(0.50)}{2 \not t(0.050-0.020)} \\ \vec{B} & =3.0 \times 10^{-6}+3.3 \times 10^{-6}\end{aligned}\right.$

1 mark $\left\{\quad \vec{B}=6.3 \times 10^{-6} \mathrm{~T}\right.$ out of the page

## Common Errors:

This question was not done well by students.

- A significant number of students left this question out.
- A large number of students could not use their calculator properly even though they had substituted values into the formula correctly.
- Many students could not distinguish between magnetic and electric fields, using an array of incorrect formulae, such as:

$$
F=B I L \sin \theta \quad B=\frac{\mu I}{2 \pi r^{2}} \quad R=\frac{\rho L}{A} \quad F=\frac{k q_{1} q_{2}}{r^{2}} \quad E=\frac{k q_{m}}{r^{2}}
$$

- The majority of students subtracted the magnetic fields instead of adding them. It appears that they are using the direction of the field in front of the wires rather than in between the wires.
- Direction was often omitted.
- Some students subtracted the currents and the distances and used these values to find the magnetic field strength.
- Others chose to only find the magnetic field strength around the left wire.
- Some students used 0.050 m for the second distance instead of 0.030 m .


## Value

$3 \% \quad 53 .(\mathrm{a})$ When light having frequency $3.0 \times 10^{15} \mathrm{~Hz}$ is shone on a certain metal, electrons are ejected. If the stopping potential of these electrons is 7.0 V , calculate the work function of this metal.
0.5 marks $\quad\left\{E_{\gamma}=W_{0}+E_{k}\right.$
0.5 marks $\quad\left\{h \cdot f=W_{0}+V \cdot Q\right.$
1.5 marks $\quad\left\{\left(6.626 \times 10^{-34}\right)\left(3.0 \times 10^{15}\right)=W_{0}+(7.0)\left(1.6 \times 10^{-19}\right)\right.$
0.5 marks $\quad\left\{W_{0}=8.7 \times 10^{-19} \mathrm{~J}=5.4 \mathrm{eV}\right.$

## Common Errors:

- A significant number of students did not understand the concept of stopping potential. They assumed that 7.0 V was equal to $E_{k \text { max }}$. Some students used the formula $E_{k \text { max }}=\frac{1}{2} m v^{2}$, where $v=7.0 \mathrm{~V}$ to calculate maximum kinetic energy, while others used $E_{k \text { max }}=m c^{2}$. In both formulae, students used the mass of the electron.
- Many students used $E_{k \max }=\frac{V_{\text {stop }}}{e}$ instead of $E_{k \max }=e V_{\text {stop }}$.
- Students did not distinguish between V and eV . Many thought they were one in the same.
- Many students found $E_{k \max }$ using $E_{k \max }=V_{\text {stop }}=(7.0)\left(1.60 \times 10^{-19}\right)=1.12 \times 10^{-16}$, then proceeded to multiply this value by $1.60 \times 10^{-19}$ once again.


## Value

$3 \% \quad$ 53.(b) Two subatomic particles with very different masses have the same de Broglie wavelength. Explain how this is possible.

1 mark $\quad\left\{\quad p=\frac{h}{\lambda} \Rightarrow \lambda=\frac{h}{p}\right.$
1 mark $\left\{\lambda=\frac{h}{m \cdot v}\right.$
$\mathbf{1}$ mark $\left\{\begin{array}{l}\text { Therefore, if the wavelength is to remain constant while the masses differ, } \\ \text { then the speeds of the particles must differ as well. }\end{array}\right.$

For example, if one particle has a mass of $2 m$, its speed must be $\frac{1}{2} v$.

## Common Errors:

- This question was poorly done by a large number of students.
- A large number of students made no connection between deBroglie wavelengths and momentum, but related energy and wavelength.
- Students commonly stated that mass had no affect on the deBroglie wavelength.
- A number of students used the universal wave equation, $c=f \cdot \lambda$. They stated that the wavelength could remain constant because the frequency changed inversely due to the speed of light being constant.


## Value

$2 \% \quad$ 53.(c) An electron in a hydrogen atom gains 0.966 eV of energy as it jumps from one energy level to another. Calculate what energy level the electron moves to if it starts at energy level 3.

Since the electron jumps to a higher energy level, it is an absorption spectra, therefore the energy is negative.
$\mathbf{0 . 5}$ marks $\left\{\begin{array}{l}\Delta E=E_{1}-E_{2} \\ \Delta E=\frac{-13.6}{n_{1}^{2}}-\frac{-13.6}{n_{2}^{2}} \\ \Delta E=-13.6\left(\frac{1}{n_{1}^{2}}-\frac{1}{n_{2}^{2}}\right)\end{array}\right.$
0.5 marks $\quad\left\{-0.966=-13.6\left(\frac{1}{3^{2}}-\frac{1}{n_{2}^{2}}\right)\right.$
0.5 marks $\left\{\begin{array}{l}0.0710=\frac{1}{9}-\frac{1}{n_{2}^{2}} \\ -0.0401=-\frac{1}{n_{2}^{2}} \\ n_{2}^{2}=24.9\end{array}\right.$
0.5 marks $\quad\left\{\quad n_{2}=4.99 \approx 5\right.$

## Common Errors:

- A number of students used the calculation of orbital radii and used this as an energy level.
- Many students did not realize that gaining energy meant that the change in energy should be written as -0.966 eV . Consequently, their calculated value was incorrect.


## Value

$2 \% \quad 53 .(d)$ Cesium- 137 has a half-life of 30.2 years and is found in the radioactive waste products of nuclear power production. Calculate the time required for the activity of a sample of cesium-137 to reduce to $18 \%$ of its original value.
0.5 marks $\quad\left\{\quad A=A_{0}\left(\frac{1}{2}\right)^{\frac{t}{t_{1 / 2}^{2}}}\right.$
0.5 marks $\quad\left\{\quad 0.18=1\left(\frac{1}{2}\right)^{\frac{t}{t_{1} / 2}}\right.$
0.5 marks $\left\{\begin{array}{l}\log (0.18)=\log \left(\left(\frac{1}{2}\right)^{\frac{t}{30.2}}\right) \\ -0.74=(-0.30)\left(\frac{t}{30.2}\right)\end{array}\right.$
0.5 marks $\quad\{t=74$ years

## Common Errors:

- Many students calculated the final activity, $A$, by taking $18 \%$ of the isotope mass number. They continued by using the isotope mass number as the initial activity, $A_{0}$. The misconception that the isotope mass number was related to the initial and final activities did not prevent students from answering the question correctly. (The final activity still represented $18 \%$ of the initial activity.)
- A large number of students used $82 \%$ of the initial activity as the final activity in their calculations.
- Most frequently, once the equations were set up, students were not able to carry through with the calculations.

TABLE 1
PHYSICS 3204: ITEM ANALYSIS SELECTED RESPONSE (PART I)

| Item | Answer | Responses |  |  |  |
| :---: | :---: | :---: | :---: | :---: | :---: |
|  |  | A | B | C | D |
|  |  | \% | \% | \% | \% |
| 1 | B | 10.8 | 61.4 | 6.7 | 21.0 |
| 2 | B | 6.3 | 92.7 | 0.9 | 0.1 |
| 3 | B | 4.2 | 94.0 | 1.5 | 0.3 |
| 4 | B | 4.4 | 66.8 | 7.2 | 21.6 |
| 5 | C | 7.1 | 3.9 | 82.3 | 6.6 |
| 6 | C | 3.6 | 11.7 | 56.3 | 27.8 |
| 7 | C | 2.0 | 2.5 | 79.7 | 15.7 |
| 8 | A | 76.8 | 7.9 | 13.2 | 2.2 |
| 9 | D | 5.5 | 12.3 | 8.6 | 72.9 |
| 10 | A | 73.0 | 4.3 | 17.6 | 5.0 |
| 11 | B | 4.4 | 76.2 | 14.5 | 4.8 |
| 12 | C | 2.1 | 1.1 | 82.4 | 14.3 |
| 13 | B | 2.0 | 96.3 | 0.9 | 0.7 |
| 14 | D | 8.2 | 15.0 | 19.3 | 57.5 |
| 15 | A | 66.0 | 6.1 | 16.0 | 11.8 |
| 16 | B | 1.7 | 81.6 | 4.1 | 12.6 |
| 17 | D | 0.5 | 0.1 | 1.7 | 97.7 |
| 18 | A | 77.9 | 1.4 | 0.7 | 19.9 |
| 19 | B | 5.3 | 83.6 | 9.2 | 1.8 |
| 20 | A | 54.1 | 8.0 | 16.5 | 20.9 |
| 21 | C | 10.3 | 6.6 | 81.7 | 1.4 |
| 22 | D | 4.3 | 13.4 | 16.0 | 66.4 |
| 23 | C | 3.4 | 4.4 | 76.9 | 15.4 |
| 24 | C | 4.6 | 4.6 | 83.0 | 7.7 |
| 25 | C | 2.8 | 19.2 | 66.5 | 11.4 |


| Item | Answer | Responses |  |  |  |
| :---: | :---: | :---: | :---: | :---: | :---: |
|  |  | A | B | C | D |
|  |  | \% | \% | \% | \% |
| 26 | B | 6.3 | 73.2 | 13.0 | 7.2 |
| 27 | B | 2.5 | 96.1 | 1.0 | 0.4 |
| 28 | C | 3.7 | 14.3 | 79.3 | 2.8 |
| 29 | C | 18.5 | 16.8 | 56.1 | 8.4 |
| 30 | B | 8.3 | 78.9 | 5.4 | 7.4 |
| 31 | B | 12.2 | 79.1 | 3.0 | 5.7 |
| 32 | A | 48.9 | 7.5 | 31.3 | 11.9 |
| 33 | A | 78.8 | 15.8 | 2.0 | 3.4 |
| 34 | A | 78.2 | 2.3 | 13.8 | 5.6 |
| 35 | D | 4.8 | 8.4 | 12.3 | 74.3 |
| 36 | B | 8.1 | 78.2 | 6.8 | 6.7 |
| 37 | D | 5.5 | 6.0 | 5.9 | 82.6 |
| 38 | C | 16.7 | 22.3 | 38.1 | 22.8 |
| 39 | A | 37.8 | 9.6 | 46.7 | 5.8 |
| 40 | A | 49.3 | 11.7 | 32.4 | 6.5 |
| 41 | C | 8.7 | 4.5 | 81.6 | 5.2 |
| 42 | D | 7.4 | 15.3 | 13.1 | 64.2 |
| 43 | D | 1.2 | 2.9 | 5.0 | 90.7 |
| 44 | B | 6.6 | 84.3 | 6.6 | 2.2 |
| 45 | C | 10.7 | 12.4 | 69.4 | 6.9 |
| 46 | B | 22.1 | 42.0 | 18.0 | 17.4 |
| 47 | B | 7.5 | 57.6 | 11.6 | 23.0 |
| 48 | D | 4.8 | 6.1 | 17.4 | 71.1 |
| 49 | D | 16.7 | 5.1 | 22.4 | 55.6 |
| 50 | B | 15.2 | 72.1 | 6.6 | 5.7 |

NOTE: Percentages may not add to $100 \%$ due to multiple responses or missing values.

TABLE 2
PHYSICS 3204 ITEM ANALYSIS
CONSTRUCTED RESPONSE (PART II)

| Item | Students <br> Completing Item | Value | Average |
| :---: | :---: | :---: | :---: |
| 51. (a) | 981 | 4 | 3.0 |
| 51. (b) | 981 | 4 | 3.0 |
| 51. (c) | 981 | 3 | 1.4 |
| 51. (d) | 981 | 3 | 1.9 |
| 51. (e) | 981 | 3 | 1.7 |
| 51. (f) | 981 | 3 | 2.0 |
| 52. (a) | 981 | 3 | 1.8 |
| 52. (b) | 981 | 3 | 2.5 |
| 52. (c) | 981 | 5 | 3.0 |
| 52. (d) | 981 | 3 | 2.1 |
| 52. (e) | 981 | 3 | 0.9 |
| 52. (f) | 981 | 3 | 1.3 |
| 53. (a) | 981 | 3 | 1.8 |
| 53. (b) | 981 | 3 | 1.3 |
| 53. (c) | 981 | 2 | 1.3 |
| 53. (d) | 981 | 2 | 1.6 |

