# Grading Standards <br> Physics 3204 <br> June 2008 

## Pre-Marking Appraisal

The examination was considered fair and had coverage of each unit of study and each level of cognitive learning as per the table of specs.

## 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

Overall performance in the Physics 3204 examination improved from June 2007 to June 2008. As in past years, however, performance was lower for items that assessed outcomes from core Labs and STSE units. Core Labs and STSE units enrich and enhance material in each unit of the course. It is essential that teachers complete all core labs and STSE units to ensure that students are prepared for the examination. On provincial examinations, core Lab and STSE outcomes are often assessed at higher levels of learning. Teachers, therefore, should assess these areas of the course in a similar manner throughout the school year. Two other areas of concern were torque and electric circuits. Students appeared to have problems with basic definitions and principles in applications of these topics.

Teachers should also encourage students to read questions carefully and critically. Very often on the provincial examination, errors occur because students fail to read the entire question. If they read the complete question or read it several times, they are less likely to misinterpret the item and are more likely to perform better. Another recurring concern was mathematical skills. Many students made errors involving the order of operations, and scientific notation. As well, many students were able to correctly select formulae and properly place values in the equations, but calculated incorrect answers.

## c) Commentary on Responses

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

Item \#15: Students should note that the only two physical forces present on the free body diagram are the tension in the string, and the force of gravity acting on the mass. The centripetal force is the result of the two previous forces.

Item \#16: Students assumed the net force was seven times the weight. They should have set up the answer as shown below:

$$
\begin{aligned}
& F_{N}=7 F_{g}=F_{C}+F_{g} \\
& \therefore 6 F g=F C \\
& r=\frac{v^{2}}{6 g}=1060 \mathrm{~m}
\end{aligned}
$$

Item \#38: This item was dropped. Including the length of the rod in the stem of the question may have led students to use the full length of the rod to calculate the magnetic force, rather than the length of the rod that actually was in the magnetic field.

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

Value
4\%
51. (a) Ball A is rolled down a $30.0^{\circ} \mathrm{ramp}$ on a 1.0 m high table, and exits the table horizontally at $2.0 \mathrm{~m} / \mathrm{s}$. A second identical ball B , is rolled down the same ramp but exits the table with a speed of $2.0 \mathrm{~m} / \mathrm{s}$ at a $30.0^{\circ}$ angle. Calculate which ball will travel the greatest horizontal distance from the base of the table.


Answer:
vertical component
$\left\{\begin{array}{l}\vec{d}=\vec{v} \cdot t+\frac{1}{2} \vec{a} \cdot t^{2} \\ -1.0=(0) \cdot t+\frac{1}{2}(-9.80) \cdot(t)^{2} \\ -1.0=-4.9(t)^{2}\end{array}\right.$
$\{t=0.45 \mathrm{~s}$
(0.5 marks)

## horizontal component

$\left\{\begin{array}{l}\vec{d}=\vec{v} \cdot t \\ \vec{d}=(2.0)(0.45) \\ \vec{d}=0.90 \mathrm{~m}\end{array}\right.$

Ball " $A$ " travels the greatest distance from the base of the table.

Students may also use the quadratic formula to determine the time for Ball " $B$ ":


## Common Errors

Students who attempted to solve this problem using the quadratic formula made errors in setting up the quadratic equation and/or solving the formula. The most common error was the omission of the negative sign for velocity and/or displacement that is directed downward.

Value
3\%
51. (b) A fish sees a bug on a tree branch that is 4.1 m above the water, and tries to knock it down by shooting a jet of water with an initial velocity of $11.7 \mathrm{~m} / \mathrm{s}$ at an angle of $35^{\circ}$ to the surface of the water. With the aid of a diagram, calculate whether it is possible for the fish to hit the bug.

## Answer:

(0.5 marks) $\left\{\begin{array}{l}\vec{v}_{2}^{2}=\vec{v}_{1}^{2}+2 \vec{a} \cdot \vec{d} \\ 0=[11.7 \sin (35)]^{2}+2(-9.80) \vec{d}\end{array}\right.$
(0.5 marks) $\quad\{\vec{d}=2.3 \mathrm{~m}$
(1 mark) Diagram

(1 mark) Since the maximum height the jet of water can reach is 2.3 m , the fish cannot hit a bug that is 4.1 m above the surface, either on the water's upward or downward movement.

## Common Errors

Students:

- used the 4.1 m height of the bug as the range.
- calculated the initial vertical velocity of the jet of water and interpreted this answer as the maximum height of the water.
- rearranged the distance formula incorrectly.
- omitted the negative sign on the acceleration due to gravity or put a negative sign on the 4.1 m giving an incorrect height.

Value
4\%
51. (c) The diagram below shows two blocks connected by a massless string over a frictionless pulley. Calculate the acceleration of the system of blocks.


## Answer:

(1 mark) $\quad\left\{\begin{array}{l}\vec{F}=m \cdot \vec{a} \\ F_{A}-f=\left(m_{1}+m_{2}\right) \cdot \vec{a}\end{array}\right.$
(0.5 marks) $\quad\left\{m_{2} g \sin \theta-\mu m_{1} g=\left(m_{1}+m_{2}\right) \cdot \vec{a}\right.$
(1 mark)

$$
\left\{\begin{array}{l}
(8.0)(9.80) \sin (25)-(0.15)(6.0)(9.80)=(6.0+8.0) \vec{a} \\
33-8.8=(14.0) \vec{a}
\end{array}\right.
$$

(0.5 marks) $\quad\left\{\vec{a}=1.7 \mathrm{~m} / \mathrm{s}^{2}\right.$

The acceleration of the system of blocks was $1.7 \mathrm{~m} / \mathrm{s}^{2}$.
(1 mark) Science \& Communication Skills

## Common Errors

Students:

- added the parallel force and the frictional force instead of subtracting.
- used cosine instead of sine to calculate the component of the gravitational force responsible for pulling the mass down the incline.

Value
3\% 51. (d) In an automatic clothes dryer a hollow drum moves the clothes in a vertical circle of diameter 0.75 m . The dryer is designed so that the clothes tumble and do not simply stick to the drum as it rotates. Calculate the speed at which the drum must rotate so that a 0.425 kg sweater at the top of the drum will just begin to tumble.

## Answer:



The drum must rotate with a speed of $1.9 \mathrm{~m} / \mathrm{s}$ so that a the sweater at the top of the drum will just begin to tumble.

## Common Errors

## Students:

- used the diameter of the drum instead of the radius.
- did not set the normal force equal to zero.

Value
3\%
51. (e) In the diagram below, spring scales are used to measure the tension in each string supporting the 1.95 kg mass. Calculate whether the system is in static equilibrium.

## Answer:

\(\left.\left.$$
\begin{array}{cl} & \text { Horizontal components }\end{array}
$$\right\} \begin{array}{l}F_{L} \cos \theta_{L}=F_{R} \cos \theta_{R} <br>

(0.5 marks) 14.0 \cos (35.0)=16.0 \cos (44.0)\end{array}\right\}\)| (0.5 marks) $\quad\{11.5 N=11.5 \mathrm{~N}$ |
| :--- |



## Vertical Components

(1 mark) $\quad\left\{\begin{array}{l}F_{L} \sin \theta_{L}+F_{R} \operatorname{sins} \theta_{R}=m g \\ 14.0 \sin (35.0)+16.0 \sin (44.0)=(1.95)(9.80)\end{array}\right.$
(0.5 marks) $\quad\{19.1 N=19.1 N$
(0.5 marks) Since both the horizontal \& vertical components balance, the system is in static equilibrium.

## Commentary on Response

A small number of students used the law of cosines to solve this question.

## Common Errors

Students:

- based their answer on vertical components balancing out or not, but ignored horizontal components.
- used weight in the $x$-component calculations.
- compared the $y$-component of the tension in one string to the $y$-component of the tension in the second string.

Value
$3 \% \quad 51$. (f) A 4.00 m long uniform beam is supported by a pivot at one end and a cable at the other end. The beam has a mass of 15.0 kg and supports a 25.0 kg box as shown. Calculate the tension, T , in the cable.


## Answer:

(1 mark) $\quad\left\{\begin{array}{l}\tau_{c w}=\tau_{c c w} \\ \tau_{B}+\tau_{M}=\tau_{C} \\ F_{B} \times r_{B}+F_{M} \times r_{M}=\left(F_{C} \sin \theta\right) \times r_{C}\end{array}\right.$
(1.5 marks)
$\{(15.0)(9.80) \times(2.00)+(25.0)(9.80) \times(2.50)=(T \cdot \sin 55.0) \times(4.00)$
(0.5 marks) $\quad\{T=277 N$

The tension in the cable is 277 N.

## Commentary on Response

A significant number of students did not seem to understand the definition of torque.

## Common Errors

Students:

- omitted the angle or distance for tension in the cable when calculating torque.
- omitted distances (radius from pivot) or used incorrect distances (distances stated rather than those measured from the pivot).
- used mass instead of determining weight $\left(\mathrm{Fg}_{\mathrm{g}}\right)$ in torque calculations.
- made computational errors.

Value
4\%
52. (a) Three charged objects are arranged as shown. Calculate the magnitude and direction of the net electric force on object B due to the presence of objects A and C .


## Answer:

(0.5 marks) $\quad\left\{F_{\text {elect }}=F_{A \rightarrow B}+F_{C \rightarrow B}\right.$
(0.5 marks)

$$
\left\{F_{\text {elect }}=\frac{k Q_{A} Q_{B}}{r_{A B}^{2}}+\frac{k Q_{C} Q_{B}}{r_{C B}^{2}}\right.
$$

(1.5 marks) $\quad\left\{F_{\text {elect }}=\frac{\left(9 \times 10^{9}\right)\left(3.0 \times 10^{-6}\right)\left(2.0 \times 10^{-6}\right)}{(0.25)^{2}}+\frac{\left(9 \times 10^{9}\right)\left(1.5 \times 10^{-6}\right)\left(2.0 \times 10^{-6}\right)}{(0.15)^{2}}\right.$
(0.5 marks)
$\left\{F_{\text {elect }}=2.1 N[R]\right.$
(1 mark) Science \& Communication Skills

## Commentary on Response

Students tended to confuse negative signs with direction (left), as opposed to an "attractive" force.

## Common Errors

Students:

- subtracted the two forces because the signs were different instead of adding them.
- found electric field strength rather than electric force.

Value
5\%
52. (b) For the circuit shown below, calculate:


Note: Although no direct marks are allocated for redrawing the diagram so that the parallel arrangement may be reduced, it is often wise to instruct students to do so!

i) the resistance of $R_{1}$.

## Answer:

$$
\begin{array}{lll}
R_{\text {total }}=\frac{V}{I} & R_{P}^{-1}=R_{2}^{-1}+R_{3}^{-1} & R=R_{1}+R_{P}+R_{4} \\
R_{\text {total }}=\frac{18}{0.50} & R_{P}^{-1}=(20.0)^{-1}+(30.0)^{-1} & 36=R_{1}+12.0+6.0 \\
\underbrace{R_{\text {(0.5 marks })}=36 \Omega}_{(\mathbf{t o t a l}} & \underbrace{R=12.0 \Omega}_{(\mathbf{0 . 5} \text { marks })} & \underbrace{R_{1}=18 \Omega} \\
& & (\mathbf{0 . 5} \text { marks })
\end{array}
$$

The resistance of $R_{1}$ is $18 \Omega$.
ii) the power dissipated in $\mathrm{R}_{4}$.

## Answer:

(0.5 marks) $\quad\left\{R_{2}, R_{P}, \& R_{q}\right.$ are in series, $\therefore I_{R}=I_{P}=I_{4}=I=0.50 \mathrm{~A}$
(1 mark) $\quad\left\{\begin{array}{l}P_{4}=I_{4}^{2} R_{4} \\ P_{4}=(0.50)^{2}(6.0)\end{array}\right.$
(0.5 marks) $\quad P_{4}=1.5$ Watts

$$
\text { The power dissipated by } R_{4} \text { is } 7.5 \text { Watts. }
$$

iii) the voltage drop across $\mathrm{R}_{2}$.

## Answer:

```
( 0.5 marks) \(\quad \quad \quad V_{2}=V_{3}=V_{p}=I_{P} \cdot R_{P}\)
( 0.5 marks \() \quad \quad \quad V_{2}=(0.50)(12.0)\)
(0.5 marks) \(\quad\left\{V_{2}=6.0\right.\) Volts
```

The voltage drop across $R_{2}$ is 6.0 Volts .

## Commentary on Response

Many students did not attempt this question. Students appeared to be confused about the current relationships of parallel \& series circuits.

## Common Errors

Students:

- found the total resistance and equated it to the resistance of the first resistor.
- used 18 V in the equation $\mathrm{P}=\mathrm{VI}$ when finding the power dissipated by the fourth resistor.
- had difficulty finding the voltage drop across the second resistor.
- did not use parallel resistance in part iii), but instead used parallel current with the individual resistance of the second resistor.

Value
3\%
52. (c) An electrical appliance runs from a 240 V power supply. A graph of power versus time for this appliance is shown below.

i) Use the graph to determine the energy dissipated by the appliance in the first 180.0 seconds.

## Answer:

Energy dissipated $=$ area under the graph line.

$$
E=\text { Area }_{(0 \rightarrow 90.0)}+\text { Area }_{(90.0 \rightarrow 280.0)}
$$

( 0.5 marks $) \quad(E=(1000.0)(90.0)+(500.0)(180.0-90.0)$
(0.5 marks) $\quad\left\{E=1.35 \times 10^{5} J\right.$

The energy dissipated is $1.35 \times 10^{5} \mathrm{~J}$.
ii) Determine the resistance of the appliance when its power consumption is 1000.0 W .

## Answer:

(0.5 marks) $\quad\left\{P=\frac{V^{2}}{R}\right.$
(1 mark) $\left\{\left\{1000.0=\frac{(240)^{2}}{R}\right.\right.$
(0.5 marks) $\quad\{R=58 \Omega$

The resistance of the appliance is $58 \Omega$.

## Commentary on Response

In part (i) of this question, many students could not link area with the power dissipated. They used the equation " $E=P \cdot t$ " but still did not relate this to area.

In part (ii), most students were able to derive the formula for heat loss and solve for resistance. Some students did the problem in two steps by first finding current and then finding resistance.

## Common Errors

Students:

- used $E=P \cdot t=1000.0 \mathrm{~W} \times 180.0 \mathrm{~s}$. They did not notice that the power dropped after 90.0 seconds.
- incorrectly derived the equation for power dissipated.

Value
$3 \% \quad$ 52. (d) An electron is moving parallel to a straight conductor that is carrying 8.5 A of current. The electron is 0.015 m away from the conductor and is moving at $7.5 \times 10^{5} \mathrm{~m} / \mathrm{s}$, in the same direction as the current. Calculate the force on the electron (magnitude and direction).


## Answer:

Due to the current in the conductor, there is an induced magnetic field around the conductor, moving into the page above the conductor, and out of the page below the conductor (LHR \#1). According to the "motor principle" (LHR \#3), there will be a force experienced up towards the top of the
 page.

$$
F=B v Q \sin \theta \quad B=\frac{\mu_{o} I}{2 \pi r}
$$

(1 mark) $\quad\left\{F=\left(\frac{\mu_{o} I}{2 \pi r}\right) v Q \sin \theta\right.$
(1 mark) $\quad\left\{F=\left(\frac{\left(4 \pi \times 10^{-7}\right)(8.5)}{2 \pi(0.015)}\right)\left(7.5 \times 10^{5}\right)\left(1.6 \times 10^{-19}\right) \sin (90)\right.$
$F=1.4 \times 10^{-17} \mathrm{~N}$
(1 mark) $\quad\left\{F=1.4 \times 10^{-17}\right.$ N [up, toward top of page]

## Commentary on Response

Most students were able to see that the formula for magnetic field strength, " $B$ ", and the formula for magnetic force " $F$ " had to be used. Many students used the correct equations but did not plug in the values properly to get the correct answer. Finding the correct direction was also a concern.

## Common Errors

Students:

- made computational errors.
- did not give the correct direction for the force.

Value
3\%
52. (e) A 0.16 kg metal rod is placed in a horizontal magnetic field of 0.75 T and maintains contact with two vertical metal rails that are separated by a distance of 0.080 m . Calculate the current that must flow through the rod in order for it to remain at rest.

## Answer:

\(\left.$$
\begin{array}{ll}\text { (1 mark) } & \left\{\begin{array}{l}F_{m a g}=F_{g} \\
B I \ell \sin \theta=m g\end{array}
$$\right. <br>

I=\frac{m g}{B \ell \sin \theta}\end{array}\right\}\)| (1.5 marks) |
| :--- |
| (0.5 marks) $\quad\left\{\begin{array}{l}(0.16)(9.80) \\ (0.75)(0.080) \sin (90)\end{array}\right.$ |



The current that must flow through the rod in order for it to remain at rest would be 26 A.

## Commentary on Response

Many students did not attempt this question while others used incorrect equations.

## Common Errors

Students used the equation for magnetic field strength, $B$, and rearranged it to solve for current, $I$.

## Value

2\%
52. (f) Two people are talking to one another on their identical cell phones. Person A holds the phone 2.0 cm from his ear, while Person $B$ holds it 6.0 cm from her ear. Explain which person will receive the greatest intensity of radio frequency radiation and state by what factor it is greater.


## Commentary on Response

Most students attempted this question but did not receive full credit. Students had little problem identifying that the person with the cell phone closer to their ear received the greatest radiation. However, they often did not discuss the inverse square law with respect to distance and many had problems finding the factor difference.

## Common Errors

Students:

- did not explain why the person with the cell phone closer to their ear received the greatest amount of radiation (inverse square law).
- gave a factor of 3 instead of 9 .
- confused sound intensity with radiation intensity.

Value
3\%
53. (a) Calculate the maximum wavelength that will cause photoelectric emission from a metal surface having a work function of 2.00 eV .

## Answer:

The maximum wavelength that will cause the photoelectric effect to occur is at the threshold energy, or the Work Function, $. \therefore E_{K}=0$.

```
(0.5 marks) \(\left\{\begin{array}{l}E=W_{0} \\ \frac{h c}{\lambda}=W_{0} \\ \lambda=\frac{h c}{W_{0}}\end{array}\right.\)
(1 mark) \(\quad\left\{=\frac{\left(6.626 \times 10^{-34}\right)\left(3.00 \times 10^{8}\right)}{2.00\left(1.60 \times 10^{-19}\right)}\right.\)
(0.5 marks) \(\quad\left\{\lambda=6.21 \times 10^{-7} \mathrm{~m}\right.\)
```

The maximum wavelength that will cause the photoelectric effect to occur is $6.21 \times 10^{-7} \mathrm{~m}$.
(1 mark) Science \& Communication Skills

## Commentary on Response

Students had difficulty with rearranging variables and calculations involving scientific notation.

## Common Errors

Students:

- did not recognize that $E_{K}=0$.
- did not convert from eV to Joules when necessary.
- calculated frequency and then tried to calculate wavelength by mistakenly stating $\lambda=1 / \mathrm{f}$.
- made computational errors.

Value
2\% 53. (b) Calculate the energy released in the reaction shown below.

$$
{ }_{3}^{6} L i+{ }_{0}^{1} n \rightarrow{ }_{2}^{4} \mathrm{He}+{ }_{1}^{3} H
$$

| Particle | Mass (u) |
| :--- | :---: |
| ${ }_{3}^{6} \mathrm{Li}$ | 6.01513 |
| ${ }_{0}^{1} n$ | 1.00867 |
| ${ }_{2}^{4} \mathrm{He}$ | 4.0026 |
| ${ }_{1}^{3} \mathrm{H}$ | 3.01604 |

## Answer:

The energy released in the reaction is due to the mass difference between the reactants \& the products. Therefore, the mass difference MUST be calculated first.
(0.5 marks)

$$
\left\{\begin{array}{l}
\Delta m=\text { mass of reactants }- \text { mass of products } \\
\Delta m=(6.01513+1.00867)-(4.0026+3.01604) \\
\Delta m=0.00516 u
\end{array}\right.
$$

(0.5 marks)

$$
\left\{\Delta m=0.00516\left(1.66 \times 10^{-27}\right)=8.57 \times 10^{-30} \mathrm{~kg}\right.
$$

(0.5 marks)
(0.5 marks)

$$
\begin{aligned}
& \left\{\begin{array}{l}
\Delta E=(\Delta m) c^{2} \\
\Delta E=\left(8.57 \times 10^{-30}\right)\left(3.00 \times 10^{8}\right)^{2}
\end{array}\right. \\
& \left\{\begin{array}{l}
\Delta E=7.71 \times 10^{-13} \mathrm{~J} \\
\text { or, } \Delta E=\frac{7.71 \times 10^{-13} \mathrm{~J}}{1.602 \times 10^{-19}}=4.81 \times 10^{6} \mathrm{eV}=4.81 \mathrm{MeV}
\end{array}\right.
\end{aligned}
$$

The energy released in the reaction was $7.71 \times 10^{-13} \mathrm{~J}$ or 4.81 MeV .

## Commentary on Response

Many students experienced difficulty with conversions and mathematical operations.

## Common Errors

Students forgot to square the speed of light.

Value
3\%
53. (c) In a photoelectric effect experiment, light was shone on a metal surface and the data below were recorded.

| Frequency of <br> incident light <br> $\left(\times 10^{14} \mathrm{~Hz}\right)$ | Maximum kinetic energy <br> of ejected electrons <br> $\left(\times 10^{-19} \mathrm{~J}\right)$ |
| :---: | :---: |
| 6 | 1 |
| 7 | 1.6 |
| 8 | 2.3 |
| 9 | 2.9 |

i) Graph these results, including the line of best fit.

## Answer:

(1 mark)

(0.5 marks) $\left\{\begin{array}{l}\text { Work function may be determined when } E_{\text {kmax }}=0, \text { the } x \text {-intercept. } \\ \text { At this point, the incident photons have a frequency of } 4.5 \times 10^{14} \mathrm{~Hz} .\end{array}\right.$

$$
E=W_{0}+E_{K}
$$

(0.5 marks) $\left\{\begin{array}{l}W_{0}=E \\ W_{0}=h f\end{array}\right.$
(0.5 marks) $\quad\left\{W_{0}=\left(6.626 \times 10^{-34}\right)\left(4.5 \times 10^{14}\right)\right.$
(0.5 marks)
$\left\{W_{0}=3.0 \times 10^{-19} \mathrm{~J}=1.9 \mathrm{eV}\right.$
The work function of the metal is $3.0 \times 10^{-19} \mathrm{~J}$ or 1.9 eV .

## Commentary on Response

In part (i), the line of best fit was poorly drawn. Many students made no connection between the graph line and the expected response to part (ii). Some students used the points in the chart to determine the work function without showing that they were on the line of best fit.

## Common Errors

Students:

- identified the $x$-intercept as the work function.
- made computational errors, especially with scientific notation.
- did not draw a correct line of best fit.

Value
2\% 53. (d) State two arguments to support, or two arguments to oppose, nuclear energy production. In support:

1. As demand for electricity increases, traditional non-renewable resources and renewable resources may not provide sufficient amounts of energy.
2. Canada has a vast supply of Uranium to meet the needs of energy production.

Students may also choose from other supporting or opposing positions that were stated in their text or discussed:

In support:

- Canada's CANDU reactors are very safe, and pose little public risk.
- Although initial capital costs are high, long-term operational costs are low.
- Traditional non-renewable resources have environmental issues.

Opposing:

- Energy conservation may mean less energy demands so there will be no need to develop nuclear energy.
- During the mining of uranium, radioactive tailings may leach into the soil \& ground water causing radioactive contamination.
- Environmental \& health issues related to exposure may take many years to manifest itself. As well, any safety breaches may be catastrophic.
- There is no permanent and safe method for radioactive waste disposal.
- The initial capital costs are large, which means such investments become centralized near major centers and populations.
- There is a fear that nuclear facilities may become terrorist targets.
- There is a possibility that uranium may be enriched for weapons.
- If safety is breached, there may be catastrophic effects with radiation released globally as happened in the meltdown at Chernobyl,Ukraine.


## Commentary on Response

Many students did not state one position, or arbitrarily stated pros and cons. Many responses gave the impression that students had not studied this outcome.

## Common Errors

Students:

- made vague and often contradictory responses.
- stated that nuclear energy emits greenhouse gases that deplete the ozone layer.
- did not state a definitive position for or against nuclear energy production.

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

| Item | Answer | Responses |  |  |  |
| :---: | :---: | :---: | :---: | :---: | :---: |
|  |  | A | B | C | D |
|  |  | \% | \% | \% | \% |
| 1 | C | 1.2 | 8.1 | 88.2 | 2.5 |
| 2 | C | 4.9 | 11.5 | 81.0 | 2.4 |
| 3 | C | 3.6 | 2.3 | 92.9 | 1.2 |
| 4 | A | 81.8 | 11.1 | 2.5 | 4.6 |
| 5 | C | 5.3 | 6.6 | 82.2 | 5.6 |
| 6 | C | 3.8 | 9.7 | 59.3 | 27.1 |
| 7 | B | 6.0 | 67.7 | 18.2 | 8.1 |
| 8 | A | 74.2 | 11.8 | 8.5 | 5.2 |
| 9 | B | 3.8 | 79.1 | 8.5 | 8.5 |
| 10 | A | 80.4 | 3.7 | 10.8 | 4.9 |
| 11 | B | 8.5 | 60.0 | 24.3 | 7.1 |
| 12 | D | 2.0 | 7.4 | 9.3 | 80.6 |
| 13 | B | 2.3 | 79.1 | 14.1 | 4.6 |
| 14 | B | 11.9 | 51.4 | 25.0 | 10.9 |
| 15 | B | 11.5 | 27.5 | 47.3 | 13.7 |
| 16 | D | 12.4 | 22.7 | 43.7 | 20.7 |
| 17 | D | 0.8 | 1.5 | 3.3 | 94.4 |
| 18 | D | 5.1 | 5.8 | 8.9 | 80.1 |
| 19 | B | 6.7 | 66.8 | 16.5 | 9.4 |
| 20 | D | 12.8 | 17.1 | 22.1 | 47.8 |
| 21 | D | 19.6 | 1.0 | 1.7 | 77.8 |
| 22 | A | 73.8 | 20.2 | 4.4 | 1.6 |
| 23 | D | 1.9 | 3.5 | 6.1 | 88.5 |
| 24 | A | 77.8 | 6.2 | 11.1 | 4.8 |
| 25 | D | 4.0 | 6.0 | 5.1 | 84.8 |


| Item | Answer | Responses |  |  |  |
| :---: | :---: | :---: | :---: | :---: | :---: |
|  |  | A | B | C | D |
|  |  | \% | \% | \% | \% |
| 26 | C | 14.8 | 5.6 | 72.5 | 6.9 |
| 27 | D | 5.0 | 14.7 | 16.7 | 63.3 |
| 28 | D | 13.6 | 14.9 | 17.5 | 53.6 |
| 29 | B | 2.8 | 93.4 | 0.9 | 2.9 |
| 30 | C | 10.4 | 6.0 | 79.7 | 3.6 |
| 31 | D | 1.5 | 1.7 | 1.5 | 95.4 |
| 32 | B | 3.6 | 92.8 | 1.7 | 1.9 |
| 33 | B | 12.1 | 62.9 | 8.7 | 16.3 |
| 34 | C | 5.8 | 8.2 | 69.6 | 16.3 |
| 35 | B | 1.6 | 85.8 | 12.1 | 0.4 |
| 36 | C | 4.3 | 14.1 | 77.2 | 4.4 |
| 37 | B | 3.9 | 80.9 | 8.7 | 6.4 |
| 38 | A | 24.7 | 15.7 | 35.7 | 23.6 |
| 39 | C | 10.1 | 24.7 | 55.1 | 10.1 |
| 40 | B | 1.4 | 83.2 | 6.5 | 8.9 |
| 41 | C | 6.5 | 23.6 | 66.4 | 3.4 |
| 42 | D | 4.1 | 41.6 | 3.4 | 50.8 |
| 43 | A | 70.6 | 10.4 | 13.1 | 5.0 |
| 44 | C | 6.8 | 11.2 | 76.4 | 5.5 |
| 45 | D | 6.5 | 7.2 | 7.8 | 78.6 |
| 46 | D | 11.2 | 28.2 | 43 | 17.2 |
| 47 | C | 26.1 | 20.4 | 36.4 | 17.1 |
| 48 | C | 5.7 | 7.0 | 74.9 | 12.4 |
| 49 | B | 11.5 | 50.8 | 35.3 | 2.4 |
| 50 | C | 9.8 | 9.0 | 76.7 | 4.3 |

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

TABLE 2
PHYSICS 3204 ITEM ANALYSIS
CONSTRUCTEDRESPONSE (PART II)

| Item | Students <br> Completing Item | Value | Average |
| :---: | :---: | :---: | :---: |
| 51. (a) | 1017 | 4 | 2.6 |
| 51. (b) | 1017 | 3 | 2.1 |
| 51. (c) | 1017 | 4 | 3.2 |
| 51. (d) | 1017 | 3 | 2.3 |
| 51. (e) | 1017 | 3 | 1.8 |
| 51. (f) | 1017 | 3 | 2.1 |
| 52. (a) | 1017 | 4 | 3.0 |
| 52. (b) | 1017 | 5 | 3.0 |
| 52. (c) | 1017 | 3 | 1.8 |
| 52. (d) | 1017 | 3 | 1.5 |
| 52. (e) | 1017 | 3 | 1.4 |
| 52. (f) | 1017 | 2 | 1.3 |
| 53. (a) | 1017 | 3 | 1.8 |
| 53. (b) | 1017 | 2 | 1.4 |
| 53. (c) | 1017 | 3 | 2.0 |
| 53. (d) | 1017 | 2 | 1.2 |

