Physics 3204
Grading Standards
June 2004

Pre-Marking Appraisal

The June 2004 physics exam was considered a fair exam, well designed, and of reasonable length and difficulty.

There were two concerns noted;

(i) In #38 there was a typing error. The speed of the plane, 2.4×10^4 m/s, should have been 2.4×10^2 m/s.

(ii) The reference to emf In #52(f) was consistent with this concept as presented in the curriculum guide.

Both these items were dropped from the exam. Part I was marked out of 49 and Part II out of 47.

Marking Standard and Consistency

Marker reliability was checked by obtaining a random sample of 50 papers that went through the marker panel and marks were assigned to each question on a separate sheet of paper. The 50 exams were put back into the original stack of exams and corrected again when they appeared. The two values were compared and if there were discrepancies, the chief marker would review the scoring with the individual marker.

Throughout the marking process there was statistical analysis run on item data to enhance reliability and consistency of marking.

Summary

This was the first provincial examination for the new program in Physics 3204. The unit distribution and format of the exam was a good representation of the course and should be continued in future years.

PART 11
Total Value: 25%

Instructions: Complete all questions in this section. Show calculations for numerical problems.

Value

2%   51(a) If a rock is thrown horizontally from a 45.0 m high cliff with a velocity of 20.0 m/s, how far from the base of the cliff does the rock hit the ground.

$$y-\text{ direction: } \vec{d}_y = \vec{v}_{oy}t + \frac{1}{2}\vec{g}t^2$$

$$-45.0\text{ m} = 0 - \frac{1}{2}(9.80)t^2 \quad (\frac{1}{2}\,mark)$$

$$t = \sqrt{\frac{45.0}{4.90}} = \sqrt{9.18} = 3.03\text{ s } (\frac{1}{2}\,mark)$$

$$x-\text{ direction: } \vec{d}_x = \vec{v}_{ox}t = (20.0)(3.03) = 60.6\text{ m } (1\ mark)$$

Commentary on Response:

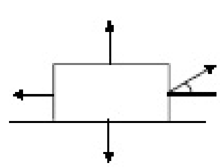
This question was well done.

Common Errors:

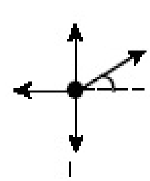
- Students did not set V_{1y} to be 0.
- Students used wrong formula to calculate time.
- Students made calculation errors using $t = 2\sqrt{\frac{45}{4.90}}$.
- Students made calculation errors using $d = \frac{vx}{t}$.

51(b) A 5.0 kg block is laid flat on an horizontal table $(\mu_K = 0.10)$. The block is pulled to the right with a force of 25 N, at 15° above the horizontal.

2%   (i) Sketch the free body diagram.



or



(½ mark for each force)

Commentary on Response:

This question was well done.

Common Errors:

- Students did not place in all the forces.
- Students did not have the Fapplied at an angle.
- Students drew free body diagram as if the mass was on an incline.

3% (ii) What is the magnitude of the acceleration of the block?

$$F_K = \mu_K \cdot F_N = (0.10)(42.5) = 4.25\text{ N} \quad (\frac{1}{2} mark)$$

$$\text{y direction: } F_N = F_g - F_A \sin\theta = mg - F_A \sin\frac{1}{2} = (5.0)(9.8) - (25)(\sin 15)$$

$$= 49 - 6.5 = 42.5 \quad (\frac{1}{2} mark)$$

$$x\text{ direction: } \vec{F}_{net} = m\vec{a}$$

$$F_A \cos\theta - f = ma \quad (1\ mark)$$

$$a = \frac{(25)(\cos 15)-(4.25)}{5.0} = \frac{19.9}{5.0} = 4.0\text{ m/s}^2 \ (1\ mark)$$

Commentary on Response:

This question was well done

Common Errors:

- Students calculated the normal Force by adding F sinθ to the weight instead of subtracting.
- Students forgot to subtract the frictional force.
- Students used cos 15 instead of sin 15.

3% 51(c) A car is moving around a horizontal curve with a radius of 50.0 m. If the coefficient of static friction is 0.75, what is the maximum speed for the car to travel safely around the curve without skidding?

$$F_c = F_{fr} \qquad F_c = ma_c \qquad F_{fr} = \frac{mv^2}{r} \;\; (\tfrac{1}{2} mark)$$

$$F_{fr} = \mu_s F_N = \mu_s mg \;\; (\tfrac{1}{2} mark)$$

$$\mu_s mg = \frac{mv^2}{r} \;\; (1\ mark)$$

$$v = \sqrt{\mu_s rg} = \sqrt{(0.75)(50.0)(9.80)} = 19\ \text{m/s} \quad (1\ \text{mark})$$

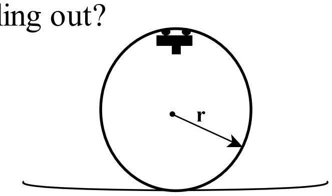
Commentary on Response:

This question was well done.

Common Errors:

- Students used the formula $r = \frac{v^2}{t \tan g}$.
- Students used $v = \sqrt{rg}$ instead of $v = \sqrt{\mu_s rg}$.
- Students did not make connection that $\vec{F}_c = \vec{F}_g$.

3% 51(d) The diagram below represents the loop of a roller coaster. If the radius of the loop is 12.0 m, what is the minimum speed, at the top of the loop, required to prevent passengers from falling out?



$$F_N + F_g = \frac{mv^2}{r} \;\; (1\ \text{mark})$$

$$F_N = 0 \;\; (\frac{1}{2}\ \text{mark})$$

$$mg = \frac{mv^2}{r} \;\; (\frac{1}{2}\ \text{mark})$$

$$v = \sqrt{rg} = \sqrt{(12.0)(9.80)} = 10.8\ \text{m/s} \quad (1\ \text{mark})$$

Commentary on Response:

This problem was well done.

Common Errors:

- Students did not recognize that $F_N = 0$ for minimum speed.
- Students made errors in solving $mg = \frac{mv^2}{r}$ for v.
- Students subtracted F_N and F_G instead of adding.
- Students did not take the square root to get the final answer.

2% 51(e) What speed is required for an object to stay in an orbit two Earth raddii above Earth's surface?

$$r = r_e + 2r_e = 3r_e$$

$$v = \sqrt{\frac{Gm}{r}} = \sqrt{\frac{(6.67 \times 10^{-11})(5.98 \times 10^{24})}{3(6.38 \times 10^{6})}} = \sqrt{2.084 \times 10^{7}} = 4.57 \times 10^{3} \text{ m/s}$$

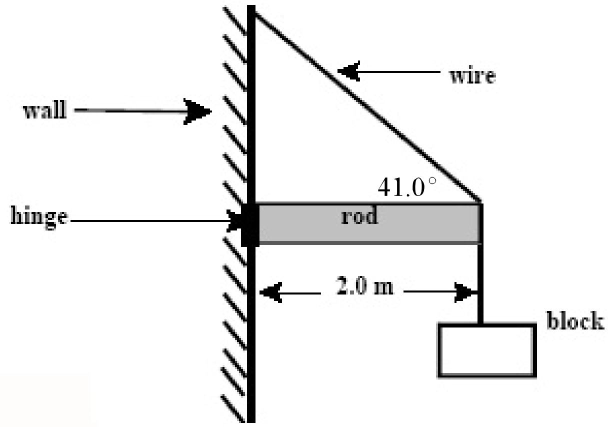
Commentary on Response:

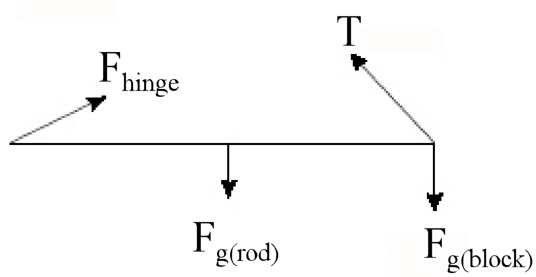
Most students used the correct constant for G, but a few used the mass of an electron instead of the mass of Earth. If a student used 2re but everything else was correctly calculated they were deducted a half mark. If they used 2re but still calculated the incorrect answer, they received a half mark.

Common Errors:

- Students used incorrect value for "r" $v = \sqrt{\frac{GM}{r}}$.
- Students used $2r_e$ instead of $3r_e$.
- Students did not get the square root.

2% 51(f)(i) Sketch the free body diagram for the rod in the diagram below. Label all forces.





(½ mark for each force)

Commentary on Response:

This question was done very poorly. A half a mark was deducted for drawing extra forces totally unrelated to problem. If all forces were given but not labelled one mark was deducted. There were no marks awarded if only component forces were shown. However, if the actual force and component forces were shown, then no marks were deducted for the components

Common Errors:

- Students drew the free body diagram from a point source.
- Students drew extra forces unrelated to problem.
- Students did not label forces.
- Students did not place force vectors in proper places (e.g., force of gravity on rod should be located at the centre of the rod).
- Students showed only component forces.
- Students omitted the force of the hinge.

3% 51(f)(ii) If the mass of the block is 5.0 kg and the rod is uniform with a mass of 0.40 kg, what is the magnitude of the tension in the wire?

let hinge be the pivot point

$$\sum \tau_{net} = 0$$

$$\tau_{ccw} = \tau_{cw}$$

$$\tau_T = \tau_{F_{g(rod)}} + \tau_{F_{g(block)}}$$

$$T\sin\theta \cdot r = m_r g \cdot \frac{r}{2} + m_b g \cdot r$$

$$T = \frac{(0.40)(9.80)(1.0) + (5.0)(9.8)(2.0)}{(\sin 41)(2.0)} = \frac{3.92 + 98}{1.31} = 77.8\text{ N} = 78\text{ N}$$

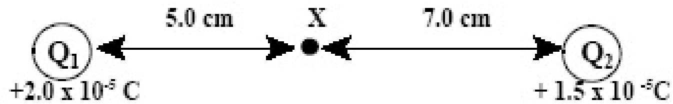
Commentary on Response:

Students often did not take into account the hinge and therefore treated this question as a static equilibrium problem instead of a torque problem. No marks were awarded if the problem was not treated as a torque problem.

Common Errors:

- Students used the correct force but incorrect distance.
- Students used *sin* instead of *cos* for the tension component.
- Students combined the mass of the rod and the block, treating it as one point.
- Students used the terms torque and force interchangeably.

3% 52(a) In the diagram below, what is the magnitude and direction of the net electric field resulting from the interaction of two fields $(\vec{\in}_1 \, and \, \vec{\in}_2)$, at point X?



$$\varepsilon_1 = \frac{(9.0\times10^9 \frac{N\bullet m^2}{C^2})(2.0\times10^{-5}C)}{(0.050m)^2} = 7.2\times10^7 \frac{N}{C} \quad (1 \, mark)$$

$$\varepsilon_2 = \frac{(9.0\times10^9 \frac{N\bullet m^2}{C^2})(1.5\times10^{-5}C)}{(0.070m)^2} = 2.76\times10^7 \frac{N}{C} \quad (1 \, mark)$$

$$\varepsilon_{NET} = \varepsilon_1 + \varepsilon_2 = 7.2\times10^7 \frac{N}{C} - 2.76\times10^7 \frac{N}{C}$$

$$\varepsilon_{NET} = 4.4\times10^7 \frac{N}{C} \quad \text{positive or right} \quad (1 \, mark)$$

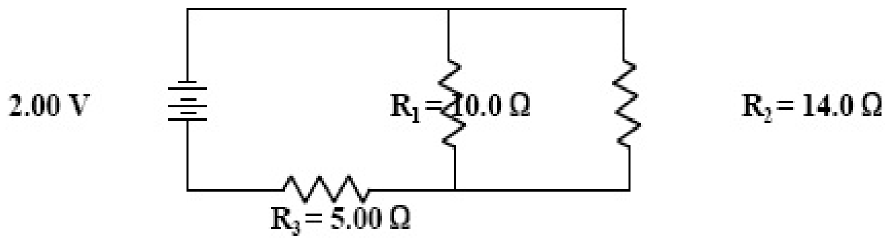
Commentary on Response:

This question was well done. There were no part marks given to students who attempted to solve this problem using Coulomb's Law.

Common Errors:

- Students used Coulomb's Law to find 2 forces instead of $\vec{\in} = \frac{kq}{r^2}$ to calculate 2 electric fields.
- Students did not convert cm into m.
- Students used the mass of a charge for "m".

52(b) Refer to the circuit diagram below to complete the questions that follow.



3% (i) For this circuit diagram, calculate: total current:

$$\frac{1}{R_p} = \frac{1}{10} + \frac{1}{14} = \frac{14+10}{140} = \frac{24}{140} \quad \therefore\ R_p = \frac{140}{24} = 5.83\ \Omega \quad \text{(1 mark)}$$

$$R_T = R_3 + R_p = 5.00 + 5.83 = 10.8\ \Omega \quad \text{(1 mark)}$$

$$I_T = \frac{V_T}{R_T} = \frac{2.00\ \text{V}}{10.8\ \Omega} = 0.185\ \text{A} \quad \text{(1 mark)}$$

Commentary on Responses:

This question was well done.

Common Errors:

- Students added all resistors as if in series.
- Students combined all resistors as if in parallel.
- Students neglected to take the reciprocal when calculating the equivalent resistance in parallel.

2% (ii) Voltage drop across R_2:

$$V_2 = V_p = I_p \cdot R_p = (0.185)(5.83) = 1.08 \text{ V}$$

OR

$$V_3 = I_3 \cdot R_3 = (0.185)(5) = 0.925 \text{ V}$$
$$V_2 = V_T - V_3 = 2.00 - 0.925 = 1.08 \text{ V}$$

Commentary on Responses:

This question was not well done.

Common Errors:

- Once finding the voltage drop across R_2, students continued to subtract that answer from the total voltage and called this the voltage drop.

1% (iii) power dissipated by the parallel section:

$$P_p = I_p \cdot V_p = (0.185)(1.08) = 0.200 \text{ W}$$

Commentary on Responses:

This question was not well done.

Common Errors:

- Most noticeable errors here were calculation errors.

3% 52.(c) A 12 V battery is connected in a circuit that contains twenty-four 40.0 Ω resistors in parallel. What is the current through each resistor?

$$\frac{1}{R_T} = \frac{24}{40} \quad \text{(1 mark)}$$

$$R_T = \frac{40}{24} = 1.67\ \Omega \quad (\frac{1}{2}\text{ mark})$$

$$I_T = \frac{V_T}{R_T} = \frac{12}{1.67} = 7.19\ \text{A} \quad (\frac{1}{2}\text{ mark})$$

$$I = \frac{I_T}{24} = \frac{7.19\ \text{A}}{24} = 0.30\ \text{A} \quad \text{(1 mark)}$$

Commentary on Response:

The question was well done.

Common Errors:

- Students left the current as the total current and did not divide by 24 to get the current through each resistor.
- Students applied series rules to the parallel circuit.

2% 52.(d) There are two types of cell phones available for commercial use. The conventional model has a headset with an antenna. The belt chin model has a headset with earphones and an antennae on the belt. Which type of cell phone has the least health risks? Explain.

The belt chin model because the intensity of radio frequencies (emr) varies with distance according to the inverse square law. The greater the distance the less the intensity.

Commentary on Response:

Most students did pick the belt-chin model as the model most likely to have the least health risks. However the explanations provided was often not correct.

Common Errors:

- Students stated that having the antenna above the head would reduce the radiation received by the brain and did not take into account increasing the distance by placing an antenna on the belt.

3% 52.(e) An electron travels with a speed of 2.00×10^6 m/s in a plane perpendicular to a 1.00×10^{-3} T magnetic field. What is the radius of the electron's path?

$$F_C = ma_c$$

$$F_{mag} = \frac{mv^2}{r}$$

$$Bqv\sin\theta = \frac{mv^2}{r} \qquad \sin\theta = 1$$

$$Bq = \frac{mv}{r}$$

$$r = \frac{mv}{Bq} = \frac{(9.11 \times 10^{-31}\ \text{kg})(2.00 \times 10^6\ \text{m/s})}{(1.00 \times 10^{-3}\ \text{T})(1.60 \times 10^{-19}\ \text{C})} = 0.0114\ \text{m} = 1.14\ \text{cm}$$

Commentary on Response:

This question was not well done. Students who had a greater knowledge went directly to the reduced formula $r - \frac{mv}{Bq}$ and easily solved this without errors.

Common Errors:

- Students calculated the magnetic fields force as Bq v sinθ but then tried to use the magnetic field around a straight conductor $B = \frac{M_o I}{2\pi r}$ or the magnetic force as $F = BIL\sin\theta$.
- Students did not relate the magnetic field's force as the centripetal force causing the circular motion.
- Students calculated the forces separately and then equated their answers to solve for the radius.
- Students made errors in working with extremely small numbers and exponential notation.

3% 52.(f) Why is there an emf induced between the wingtips of an aircraft moving at 700.0 m/s in level flight directly above Earth's magnetic North Pole? (Assume Earth's magnetic field vector is pointing straight up as the plane flies over the North Pole.)

This question was omitted. (see pre-marking appraisal).

3% 53.(a) A 1.00×10^2 W light bulb emits visible light at a wavelength of 5.00×10^2 nm.

(i) How much energy does the emitted photons contain?

$$E = hf = \frac{hc}{\lambda} = \frac{(6.63 \times 10^{-34})(3.00 \times 10^{8})}{5.00 \times 10^{-7}} = 3.98 \times 10^{-19}\ J = 2.49\ eV$$

(ii) How much energy is emitted by the light bulb in 1.00 s?

$$P = \frac{E}{t} \therefore E = P \cdot t = (100\ W)(1.00\ s) = 100\ J$$

(iii) How many photons are emitted in 1.00 s?

$$E = \frac{nhc}{\lambda} \therefore n = \frac{E\lambda}{hc} = \frac{(100)(5.00 \times 10^{-7})}{(6.63 \times 10^{-34})(3.0 \times 10^{8})} = 2.51 \times 10^{20}$$

Commentary on Response:

Students did well on part (ii). Part (iii) was not well done. because students did not equate the ratio of the total energy emitted by the light bulb to the energy per photon.

Common Errors:

- Students did not convert the nm to m.
- Students used λ for *f*.
- Students used the photoelectric equation $hf = E_K + W_o$ and took W_o as 100J.

2% 53.(b) A 2.72×10^{15} Hz photon acquires 1.1×10^{-18} J of kinetic energy. What is the work function of the metal?

$$hf = W_o + E_K$$

$$W_o = hf - E_K = (6.63 \times 10^{-34}\ J)(2.72 \times 10^{15}\ Hz) - (1.1 \times 10^{-18} J) = 7.0 \times 10^{-19}\ J$$

Commentary on Response:

Students set up the problem correctly and recognized the fact that it was a photoelectric effect problem. Most students who attempted the problem received at least 1 mark and a high percentage received full marks.

Common Errors:

- Students made calculation errors.

2% 53.(c) What is the frequency of photons that have a momentum of 2.80×10^{-27} kg · m/s?

$$p = \frac{h}{\lambda}$$

$$\lambda = \frac{h}{p} = \frac{(6.63 \times 10^{-34})}{(2.80 \times 10^{-27})} = 1.27 \times 10^{15}\ Hz$$

OR

$$p = \frac{fh}{c}$$

$$f = \frac{pc}{h} = \frac{(2.80 \times 10^{-27})(3.00 \times 10^{8})}{(6.63 \times 10^{-34})} = 1.27 \times 10^{15}\ Hz$$

Commentary on Response:

Students who attempted this question generally received full marks.

Common Errors:

- Students mistook Compton's momentum $p = \frac{h}{\lambda}$ and conservation of momentum $(p = mv)$.
- Students tried to use p = mv in this problem getting the mass from $E = mc^2$.
- Students stopped when they found λ calling it the frequency.
- Students used $f = \frac{hc}{p}$ instead of $f = \frac{pc}{h}$.

3% 53.(d) Radium-226 undergoes the following radioactive decay: ${}^{226}_{88}Ra \rightarrow {}^{222}_{86}Rn + {}^{4}_{2}He$

How much energy is released given the masses below?

$$1u = 1.66 \times 10^{-27}\text{kg} = 31.5\text{MeV} / \text{c}^2$$

isotope	mass (u)
${}^{226}_{88}Ra$	226.0244
${}^{222}_{86}Rn$	222.0164
${}^{4}_{2}He$	4.0026

$$\Delta m = m_{before} - m_{after} = 226.0244u - 226.019u = 5.4 \times 10^{-3} u$$

$$E = mc^2 = (5.4 \times 10^{-3} u)(931.5 \tfrac{\text{MeV}}{u}) = 5.03 \text{ MeV}$$

OR

$$\Delta\text{m} = 5.4 \times 10^{-3} \text{ u} \times \frac{1.66 \times 10^{-27} \text{ kg}}{\text{u}} = 8.964 \times 10^{-30} \text{ kg}$$

$$\text{E} = \Delta\text{mc}^2 = (8.964 \times 10^{-30} \text{ kg})(931.5 \frac{\text{MeV}}{\text{u}}) = 8.067 \times 10^{-13} \text{ J}$$

Commentary on Response:

Most students recognized that this was an alpha decay reaction and that $E = mc^2$ needed to be used and most students who attempted this problem received some marks.

Common Error:

- Students changed $u \rightarrow kg$ first and rounded. This gave improper number of significant digits and an answer that was too high.
- Students added up all masses instead of subtracting products from reactants.
- Students plugged 0.0054u into $E = mc^2$ without changing to kg first.
- Students did not square the "c" in $E = mc^2$

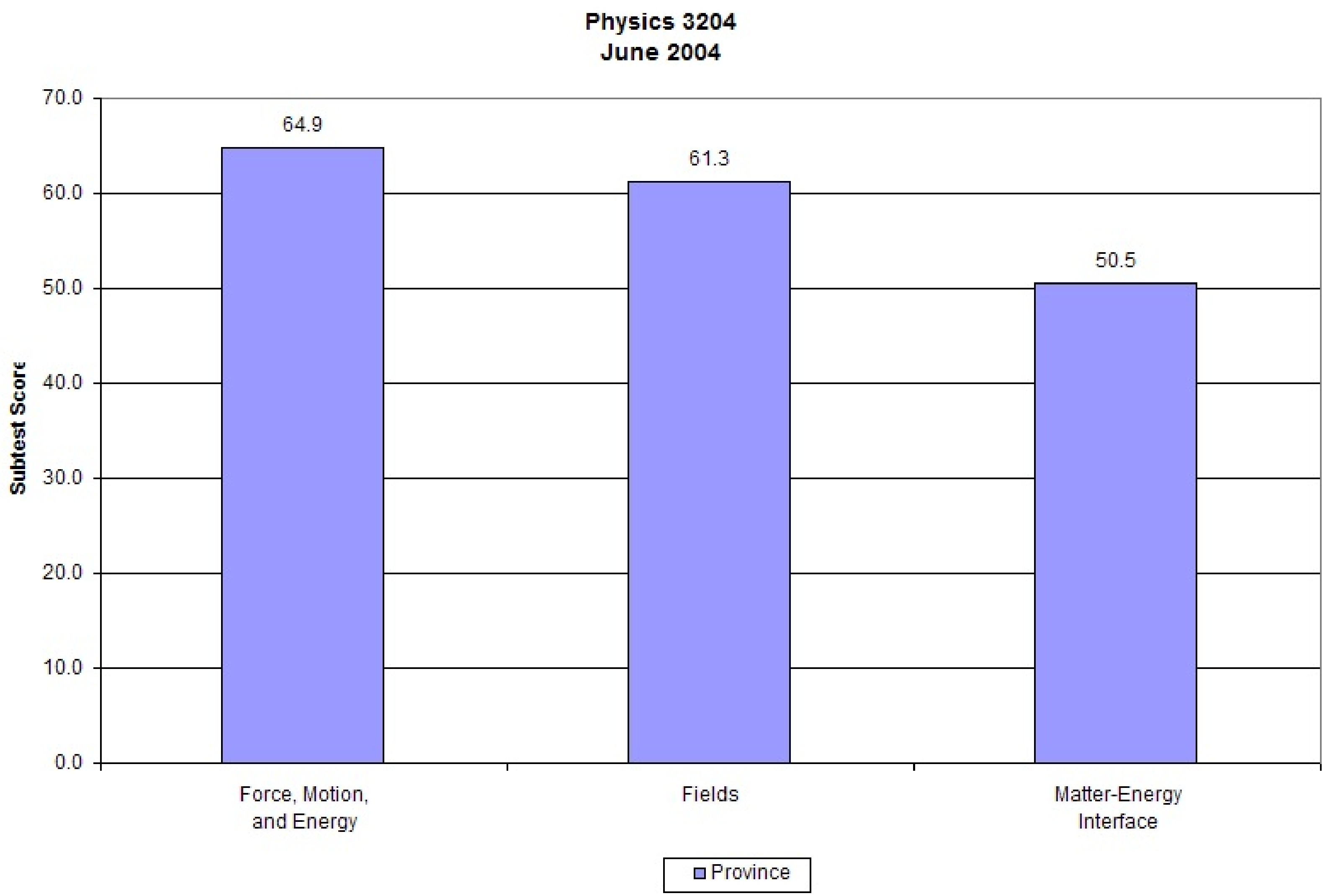
PHYSICS 3204 ITEM ANALYSIS
SELECTED - RESPONSE (PART I)

Item	Answer	Cognitive Level	Responses				
			Multiple Answers or No Response	A	B	C	D
			%	%	%	%	%
1	D	1	0	11.1	5.5	1.8	81.6
2	B	1	0	5.8	92.5	1.4	0.3
3	C	2	0.4	3.6	6.4	80.3	9.4
4	B	2	0.9	18.9	63.8	9.7	6.7
5	D	3	0.1	8.1	27.5	8.9	55.4
6	B	2	0.1	17.8	61.4	7.9	12.7
7	A	2	0.2	80.5	9	5.3	5
8	B	2	0.1	5.8	92.5	1.1	0.5
9	B	2	0.2	9.6	72	8.4	9.8
10	A	2	0.3	55.6	8.5	21.4	14.2
11	B	2	0.2	7.1	71	15	6.7
12	B	1	0.2	14.7	68.4	1.3	15.5
13	D	1	0.5	4.8	78.1	4.8	11.8
14	A	2	0.1	14.5	75.9	5.5	4.1
15	D	1	0.3	7.3	4.3	6.8	81.3
16	C	2	0.5	7.3	11.6	73.8	6.8
17	B	1	0.2	12.3	79	3.5	5
18	C	1	0.1	4.1	1.8	92.5	1.4
19	C	2	0	1.4	5.5	86	7.1
20	A	2	0.8	50.1	18.1	19.1	11.9
21	A	1	0	69.8	23.6	3.1	3.5
22	C	2	0	8.6	3.8	75.8	11.9
23	A	2	0.2	38.1	42.5	13.8	5.4
24	D	1	0.4	3.9	15.8	10.5	69.5
25	C	1	0.3	13.5	16.2	63.9	6.1

Item	Answer	Cognitive Level	Responses				
			Multiple Answers or No Response	A	B	C	D
			%	%	%	%	%
26.	C	2	.0	20.0	9.7	66.0	4.2
27.	C	1	.1	.6	10.3	82.8	6.2
28.	B	2	.1	9.4	69.8	4.1	16.7
29	A	1	0.3	70.5	3.7	3.6	21.9
30	B	2	0.2	5.5	67.9	7.2	19.2
31	C	2	0.5	5.2	16.7	67.3	10.4
32	C	2	1.1	6.5	12.5	58.4	21.5
33	C	3	0.1	13.2	41.1	31.4	14.3
34	A	1	0	81	17	1.2	0.8
35	B	1	0.1	8.6	62	26.2	3.2
36	B	2	0	25.5	47.8	12.7	14
37	B	2	0	1.9	67.8	2.3	27.9
38			**ITEM OMITTED**				
39	A	2	0.1	61.9	9.7	21.4	6.8
40	B	3	0	28	38.4	15.5	18.1
41	C	1	0	6	53.1	37.7	3.2
42	D	2	0.5	2.9	9.9	19.3	67.4
43	C	2	0.3	3.5	31.2	5.9	59.2
44	B	2	0.6	14.1	67.7	12.7	5
45	D	3	0.2	7.7	27.7	47.6	16.9
46	A	1	0	66.9	11.8	13.9	7.4
47	B	1	0	17.9	4.1	3.7	74.2
48	B	1	0.2	5.1	75.9	12.3	6.5
49	C	2	0.1	12.9	9.1	73.6	4.3
50	A	2	0.2	48.9	44.9	3.7	2.3

PHYSICS 3204 ITEM ANALYSIS
CONSTRUCTED - RESPONSE (PART II)

Item	Cognitive Level	Students Completing Item	Value	Average	Average % Per Item
51(a)	2	1107	2	1.3	65
51(b)(i)	2	1107	2	1.7	86.8
51(b)(ii)	2	1107	3	2.1	68.6
51(c)	3	1107	3	1.7	56.7
51(d)	3	1107	3	1.9	64.4
51(e)	2	1107	2	1.3	64.2
51(f)(i)	2	1107	2	0.9	43.3
51(f)(ii)	2	1107	3	1.5	48.5
52(a)	2	1107	3	1.7	57.9
52(b)(i)	2	1107	3	2.3	77.2
52(b)(ii)	2	1107	2	1	48.2
52(b)(iii)	2	1107	1	0.5	49.5
52(c)	2	1107	3	2	65.1
52(d)	2	1107	2	1.6	79.6
52(e)	3	1107	3	1.1	36.9
52(f)	ITEM OMITTED				
53(a)	2	1107	3	0.9	29.9
53(b)	2	1107	2	1.4	69.1
53(c)	2	1107	2	1.1	54.9
53(d)	3	1107	3	1.4	45.8


Physics 3204
June 2004
70.0
60.0
50.0
40.0
30.0
20.0
10.0
0.0
Subtest Score
64.9
61.3
50.5
Force, Motion, and Energy
Fields
Matter-Energy Interface
Province