NOVA SCOTIA
Department of Education
Testing and Evaluation

NOVA SCOTIA EXAMINATIONS

PHYSICS 12

JANUARY 2005

MARKING GUIDE

January 2005 Physics 12
Selected Response Questions Answer Key
Total Value 40

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1. **D**	ACP-1	21. **D**	ACP-2
2. **B**	ACP-1	22. **D**	ACP-2
3. **A**	ACP-1	23. **C**	ACP-2
4. **D**	326-4	24. **D**	328-5
5. **B**	326-4	25. **C**	328-6
6. **A**	326-3	26. **A**	328-7
7. **A**	325-6	27. **B**	328-5
8. **B**	325-6	28. **D**	327-10
9. **C**	325-6	29. **C**	327-10
10. **D**	325-12	30. **D**	327-10
11. **B**	325-13	31. **B**	329-3
12. **D**	325-12	32. **A**	329-2
13. **C**	325-12	33. **C**	327-11
14. **D**	325-13	34. **B**	329-4
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16. **C**	327-4	36. **A**	329-4
17. **D**	327-4	37. **D**	326-9
18. **B**	327-4	38. **C**	115-5 (reactors)
19. **A**	327-4	39. **B**	115-5 (reactors)
20. **D**	327-4	40. **A**	329-6

41. On a sunny afternoon, you are outside playing with your dog. You throw a tennis ball at an angle of 60.0° above the horizontal at an initial speed of 10.0 m/s and from an initial height of 2.00 m. If the dog was standing beside you when you threw the ball, how far would the dog have to run to catch the ball **just** as it hits the ground? **value: 7**

$v = 10.0$ m/s @ 60.0°

$v_{ix} = (10.0\text{ m/s})\cos 60.0°$ $v_{ix} = 5.00$ m/s **value: 0.5**

$v_{iy} = (10.0\text{ m/s})\sin 60.0°$
$v_{iy} = 8.66$ m/s **value: 0.5**

When the ball is rising:

$v_{fy}^2 = v_{iy}^2 + 2ad$
$d = (v_{fy}^2 - v_{iy}^2)/2a$
$d = ((0.0\text{ m/s})^2 - (8.66\text{ m/s})^2)/(2)(-9.81\text{ m/s}^2)$
$d = 3.82$ m **value: 2**

Therefore, the ball reaches a maximum height of 5.82 m. **value: 1**
(3.82 m + 2.00 m)

$v_f = v_i + at$
$t = (v_f - v_i)/a$
$t = (0.0\text{ m/s} - 8.66\text{ m/s})/(-9.81\text{ m/s}^2)$
$t = 0.883$ s (to rise) **value: 0.5**

When the ball is falling:

$d = v_{iy}t + ½at^2$

Since v_{iy} is 0:

$d = ½at^2$
$t^2 = 2d/a$
$t^2 = (2)(-5.82\text{ m})/(-9.81\text{ m/s}^2)$
$t^2 = 1.19\text{ s}^2$
$t = 1.09$ s (to fall) **value: 1**

Therefore, the total time is 1.09 s + 0.883 s = 1.97 s **value: 0.5**

For the horizontal range:

$v = d/t$

$d = v_{ix}t$

$d = (5.00 \text{ m/s})(1.97 \text{ s})$

$d = 9.85 \text{ m}$

Therefore, the dog ran 9.85 m. **value: 1**

A much shorter solution using the quadratic formula and the displacement equation is also possible. Score appropriately.

42. A space station is orbiting 250. km above the Earth's surface.

A) Determine the orbital speed of the space station. **value: 4**

B) How many minutes does it take for each orbit? **value: 2**

A) $r = R_E + h = 6.38\times10^6\text{m} + 2.50\times10^5\text{m} = 6.63\times10^6\text{ m}$ **value: 1**

$F_c = F_g$

$\frac{m_s v^2}{r} = \frac{G m_E m_s}{r^2}$

$v = \sqrt{\frac{G m_E}{r}}$ **value: 2**

$v = \sqrt{\frac{(6.67\times10^{-11}\text{Nm}^2/\text{kg}^2)(5.98\times10^{24}\text{kg})}{6.63\times10^6\text{ m}}}$

$v = 7760\text{ m/s}$

value: 1

The orbital speed of the space station is 7760 m/s.

B)

$v = \frac{2\pi r}{T}$

$T = \frac{2\pi r}{v}$

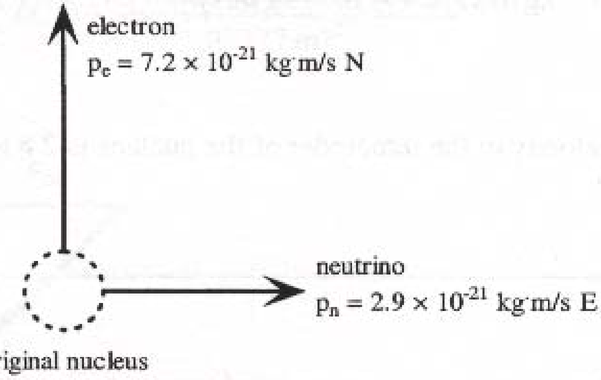
$T = \frac{2\pi(6.63\times10^6\text{m})}{7760\text{ m/s}}$ **value: 1**

$T = 5370\text{ s}$

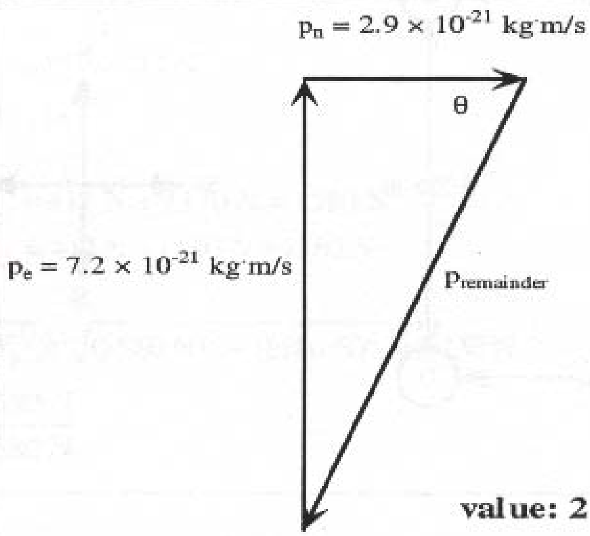
$T = 89.5\text{ minutes}$

It would take 89.5 minutes to complete one orbit. **value: 1**

43. An atomic nucleus, initially at rest, decays radioactively into three pieces that then travel in the same plane. Two of the pieces are shown below:



The remainder of the nucleus travels in an unknown direction. If the remainder of the nucleus has a mass of 2.8×10^{-25} kg, what is its velocity? Your solution **must** include a suitable vector diagram. **value: 7**



value: 2

$(p_{remainder})^2 = (p_n)^2 + (p_e)^2$
$(p_{remainder})^2 = (2.9 \times 10^{-21}\ \text{kg·m/s})^2 + (7.2 \times 10^{-21}\ \text{kg·m/s})^2$
$p_{remainder} = 7.8 \times 10^{-21}$ kg·m/s **value: 2**

$p_{remainder} = m_{remainder}v_{remainder}$
$v_{remainder} = p_{remainder}/m_{remainder}$
$v_{remainder} = (7.8 \times 10^{-21}\ \text{kg·m/s})/(2.8 \times 10^{-25}\ \text{kg})$
$v_{remainder} = 2.8 \times 10^{4}$ m/s **value: 1**

$\tan\theta = p_e/p_n$

$\tan\theta = (7.2 \times 10^{-21}\ \text{kg·m/s})/(2.9 \times 10^{-21}\ \text{kg·m/s})$

$\tan\theta = 2.5$

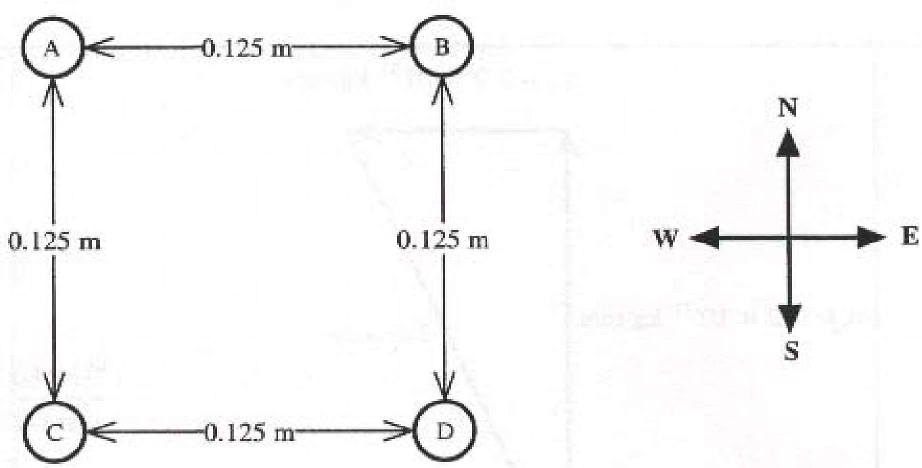
$\theta = 68°$

value: 1

Therefore, the velocity of the remainder of the nucleus is 2.8×10^4 m/s [W 68° S].

value: 1

44. Four +45.0 μC charges are arranged in a square as shown below. Determine the net force on charged particle C. Include in your answer a force vector diagram. **value: 7**



$$F_{AC} = k\frac{q_A q_C}{r^2}$$

$$F_{AC} = (8.99\times10^9\ \text{Nm}^2/C^2)\frac{(4.50\times10^{-5}\ \text{C})(4.50\times10^{-5}\ \text{C})}{(0.125\ \text{m})^2}$$

$$F_{AC} = 1170\ \text{N}$$

value: 1

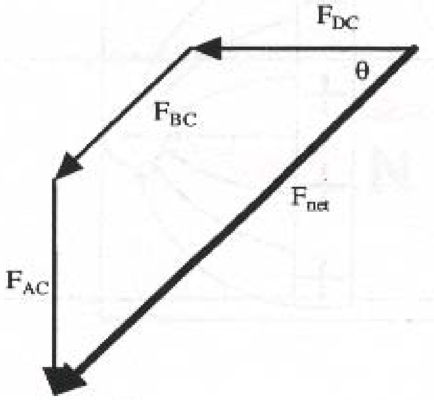
$$F_{DC} = F_{AC} = 1170\ \text{N}$$

$$F_{BC} = k\frac{q_B q_C}{r^2}$$

$$F_{BC} = (8.99\times10^9\ \text{Nm}^2/C^2)\frac{(4.50\times10^{-5}\ \text{C})(4.50\times10^{-5}\ \text{C})}{(0.177\ \text{m})^2}$$

$$F_{BC} = 581\ \text{N}$$

value: 1



value: 1

$$F_{BCx} = (581\ \text{N})\cos 45 \quad = 411\ \text{N}$$

$$F_{BCy} = F_{BCx} = 411\ \text{N}$$

value: 1

$$F_x = F_{BCx} + F_{DC} = 411\ \text{N} + 1170\ \text{N} = 1580\ \text{N}$$

$$F_y = F_{BCy} + F_{AC} = 411\ \text{N} + 1170\ \text{N} = 1580\ \text{N}$$

value: 1

$$|F_{net}| = \sqrt{F_x^2 + F_y^2} = \sqrt{(1580\ \text{N})^2 + (1580\ \text{N})^2} = 2230\ \text{N}$$

$$\tan\theta = \frac{F_y}{F_x} = \frac{1580\ \text{N}}{1580\ \text{N}}$$

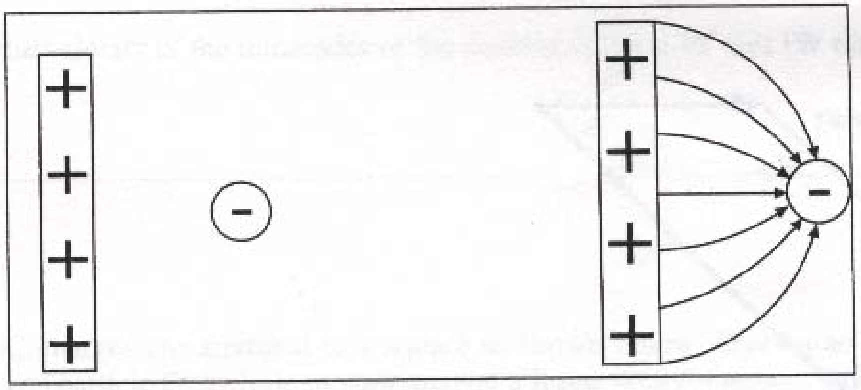
$$\theta = 45^o$$

$$\vec{F}_{net} = 2230\ \text{N [W45°S]}$$

value: 2

The net force on particle C is 2230 N, in a direction [W45°S].

45. A) On the diagram below, draw in appropriate lines that show the electric field between the negatively-charged sphere and the positively-charged plate. **value: 2**



B) Why can "g" have units of N/kg or m/s^2 ? **value: 2**

$g = F_g/m$ has units of N/kg

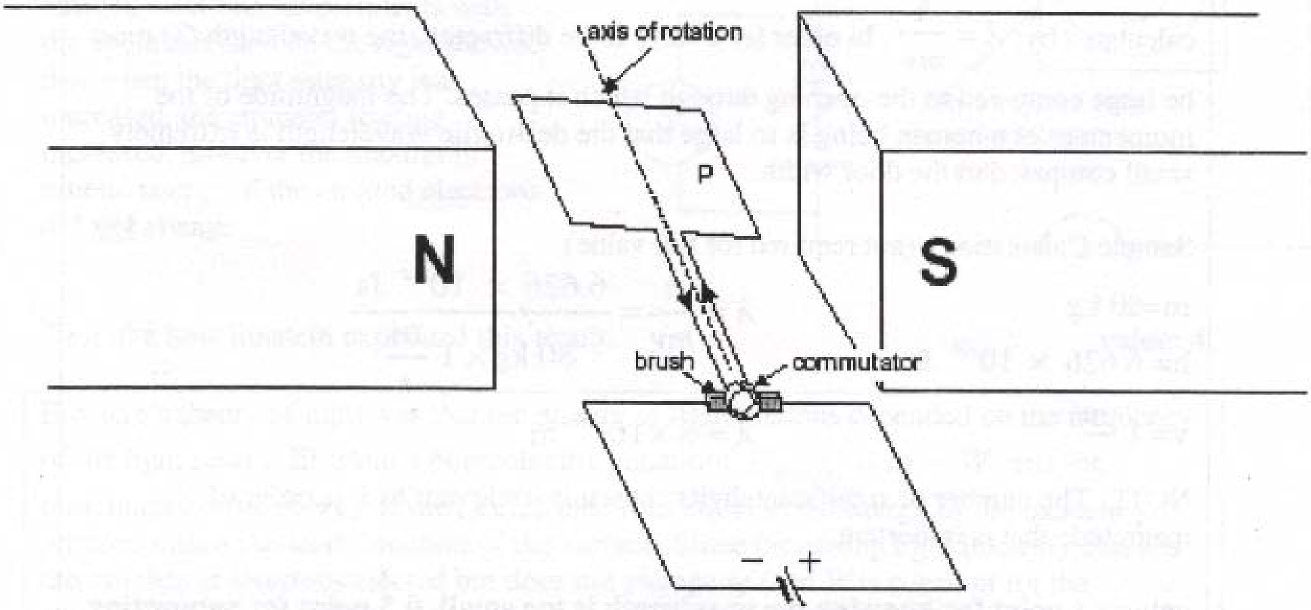
$N/kg = kg\ m/s^2/kg = m/s^2$

C) Find the gravitational field strength, "g", acting on a satellite orbiting Earth with an orbital radius of 42 000 km. **value: 2**

$F_g = Gmm_e/r^2$
$F_g/m = Gm_e/r^2$
$g = Gm_e/r^2$
$g = (6.67 \times 10^{-11}\ Nm^2/kg^2)(5.98 \times 10^{24}\ kg)/(4.2 \times 10^7\ m)^2$
$g = 0.23\ N/kg$

Therefore, the gravitational field strength acting on the satellite is 0.23 N/kg.

46. The circuit of a simple DC electric motor is shown in the figure below. It consists of a current-carrying coil of 50 turns as the armature. The coil is square with sides of 0.05 m. The coil is in a uniform magnetic field of strength 0.005 T. A current of 3.0 A flows through the coil in the direction shown in the diagram by the arrows.



A) When the coil is in the position shown in the diagram, indicate the direction of the force on side P of the wire. **value: 1**

B) What happens to the direction of the force on side P when the direction of the current is reversed? **value: 1**

C) Give 2 different ways that the armature could be made to spin faster. **value: 2**

A) The direction of the force is down.

B) The direction of the force will now be up. Full points should also be awarded if students indicate that the direction is opposite to their answer in (A).

C) Possible answers include:
increase the current
increase the amount of wire in the field
increase the magnetic field strength
lubrication

47. A) When you walk through a doorway, you represent a particle having momentum and, therefore, having a wavelength. Why is it improbable that you will be "diffracted" as you pass through the doorway? **value: 2**

According to deBroglie's wave behavior of matter, wavelength of a particle can be calculated by: $\lambda = \frac{h}{mv}$. In order for a wave to be diffracted, the wavelength (λ) must be large compared to the opening through which it passes. The magnitude of the momentum of a human being is so large that the deBroglie wavelength is extremely small compared to the door width.

Sample Calculation: (not required for full value)

m=80 kg

h= 6.626×10^{-34} Js

v= $1 \frac{m}{s}$

$$\lambda = \frac{h}{mv} = \frac{6.626 \times 10^{-34} \text{ Js}}{80 \text{ kg} \times 1 \frac{\text{m}}{\text{s}}}$$

$$\lambda = 8 \times 10^{-36} \text{ m}$$

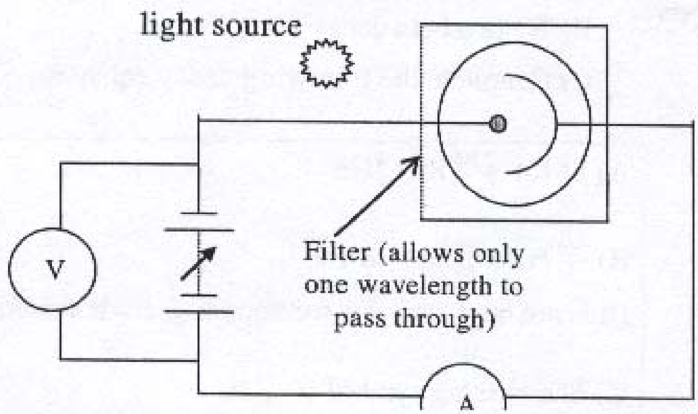
NOTE: The number of significant digits chosen is irrelevant as it is order of magnitude that is important.

values: 1 point for knowing the wavelength is too small, 0.5 point for supporting argument, 0.5 point for comparing wavelength to door opening

B) Some science fiction writers use a large sail to enable a space vehicle to move through space. They argue that sunlight will exert a pressure on the sail, causing it to move away from the sun. Explain which Quantum Theory experiment supports this claim and how. **value: 2**

Compton's experiment showing that photons have momentum supports this claim. As the photons strike the sail, they lose momentum. According to the conservation principle, the sail must gain the momentum lost by the photon.

C) According to the wave theory of light, increasing the light intensity shone on a photo-emissive surface should increase the kinetic energy of emitted electrons. Experiments with the apparatus seen on the right showed that when the light intensity was increased, the ammeter reading increased, however the maximum kinetic energy of the emitted electrons did **not** change.



Describe how Einstein explained this result. **value: 4**

Einstein's theory of light was that the energy of light photons depended on the frequency of the light source. Einstein's photoelectric equation: $E_{K\,(\max)} = hf - W$ sets the maximum kinetic energy of the ejected electrons equal to the energy of the incident photons minus the work function of the surface. Since increasing light intensity changes the number of electrons ejected but does not change hf (and W is constant for the surface), we would expect an increase in the ammeter reading but not $E_{K\,(\max)}$.

values: 1 point for indicating photon energy depends on light frequency, 1 point for expressing the relationship of kinetic energy and work function, 1 point for indicating that light intensity changes the number of photons emitted, 1 point for indicating that increasing the intensity changes the number of photoelectrons emitted, not their maximum kinetic energy.

48.A) Write an alpha decay equation for $^{223}_{88}\text{Ra}$. **value: 2**

B) Write a beta decay for $^{218}_{84}\text{Po}$. **value: 2**

C) Complete the following decay equation: $^{192}_{77}\text{Ir} \rightarrow ? + \gamma$ **value: 1**

A) $^{223}_{88}\text{Ra} \rightarrow ^{219}_{86}\text{Rn} + ^{4}_{2}\text{He}$ **value: 2**
B) $^{218}_{84}\text{Po} \rightarrow ^{218}_{85}\text{At} + ^{0}_{-1}\text{e} + \overline{\nu}$ **value: 2** (It is not necessary for students to include the antineutrino, $\overline{\nu}$)
C) The missing symbol is $^{192}_{77}\text{Ir}$ **value: 1**

CASE STUDY ANSWERS

49. A) Answers must include 3 of the following five and be written in complete sentences

- Expensive to operate
- Limited passenger capacity
- Dirty
- Noisy
- Stress on tires **value: 1**

B) These planes lack a tail rudder, are mostly wing, have the engines placed near the rear. (Two of these three are enough for full value.) **value: 1**

C) The velocity will increase by a factor of $\sqrt{\frac{4}{3}}$ which is 1.15 times. **value: 2**

D) The velocity because its effect relates to the square of its value. **value: 2**

E) Either plane could be supported. **value: 4**

Airbus

- Less infrastructure change necessary
- Fewer design problems
- Windows
- Does not have BWB problems of cabin pressure, aerodynamics, and propulsion

BWB

- More fuel efficient, better for environment
- Gear placement away from fuel tanks therefore safer
- Cheaper to run
- Bigger passenger load
- Less maintenance because of better structural integrity