

# NOVA SCOTIA EXAMINATIONS

## PHYSICS 12

**JUNE 2004**

### Comment Box—For Use by Teacher

What adaptations have been made?

By whom?

Position/Title:

Why?



Name: \_\_\_\_\_

### **General Instructions**

This examination is composed of three sections, each with an estimated time allotment shown below. Questions are in order of content, not difficulty. Unless otherwise specified, assume air friction is negligible, pulleys are massless and frictionless, and ropes are massless and do not stretch.

<u>Question Type</u>	<u>Value</u>	<u>Suggested Time</u>
Selected Response	40	60 minutes
Constructed Response	50	90 minutes
Case Study	10	30 minutes

NOTE: Times are suggestions only.

**Total Time: 3 Hours**

**Calculators are permitted but are not to be shared. Calculator memories must be cleared before the examination begins.**

### **Selected Response Questions**

(Total Value: 40)

In this part of the examination, there are forty multiple choice questions, each with a value of one point. Read each question carefully, and decide which of the choices **best** answers the question. You are provided with a separate response form. Your responses must be entered in the spaces numbered 1-40 in section 1 on side 1 of the response form. Fill in the space that corresponds to your choice using an HB pencil. If you change your answer, **erase** your previous selection completely. See the example below.

#### **Example**

#### **Answer Sheet**

Which of the following is  
a SI unit of distance?

**A B C D**

○ ○ ○ ●

- A. cubit
- B. foot
- C. inch
- D. metre

**When you finish, insert the response form in the test booklet before turning it in.**

**Please do not turn this page to start until told to do so by the invigilator.**



1. In a collision between two objects that stick together and move together after impact, there can be conservation of which of the following?
  - A. momentum but not kinetic energy
  - B. kinetic energy but not momentum
  - C. both momentum and kinetic energy
  - D. neither momentum nor kinetic energy
2. A curling stone traveling East collides with an identical stationary stone. If the stone that was originally at rest travels in a direction  $[E45^\circ N]$  after the collision, in what direction will the first stone travel after the collision?
  - A. between North and East
  - B. between East and South
  - C. between South and West
  - D. between West and North
3. From the top of a cliff 50. m high, an object is thrown horizontally at a velocity of 20. m/s. What time does it take for the object to hit the ground below?
  - A. 2.3 s
  - B. 3.2 s
  - C. 5.1 s
  - D. 10. s
4. Which of the following **does not** affect the total time in air of a projectile?
  - A. the acceleration due to gravity
  - B. the initial height
  - C. the initial horizontal velocity
  - D. the initial vertical velocity
5. How does the force of gravity affect the motion of a ball thrown horizontally?
  - A. The ball accelerates at the same rate as a ball falling from rest.
  - B. The ball begins to fall vertically only when it begins to slow down.
  - C. The ball falls at a speed that is proportional to the horizontal velocity.
  - D. The ball is not affected by gravity because it has a horizontal velocity.

6. Which of the pairs of equations below may be used to calculate the vertical displacement ( $\vec{d}_v$ ) and the horizontal displacement ( $\vec{d}_h$ ) for an object projected horizontally with a velocity ( $\vec{v}$ )?

A.  $\vec{d}_v = \vec{v} t$        $\vec{d}_h = \frac{1}{2} \vec{a}_g t^2$

B.  $\vec{d}_v = \frac{1}{2} \vec{v} t^2$        $\vec{d}_h = \vec{a}_g t$

C.  $\vec{d}_v = \frac{1}{2} \vec{a}_g t^2$        $\vec{d}_h = \vec{v} t$

D.  $\vec{d}_v = \vec{a}_g t^2$        $\vec{d}_h = \frac{1}{2} \vec{v} t$

7. An object is launched with a velocity of 20.0 m/s at an angle  $30.0^\circ$  above a horizontal surface. What is the magnitude of the velocity at the highest point in the path?

- A. 0 m/s
- B. 10.0 m/s
- C. 17.3 m/s
- D. 20.0 m/s

8. Which of the following statements actually describes a characteristic of the force that acts on an object and causes it to move in a circle?

- A. It balances all other forces.
- B. It is in the same direction as the object's velocity.
- C. It is directed toward the center of the circle.
- D. It is directed away from the center of the circle.

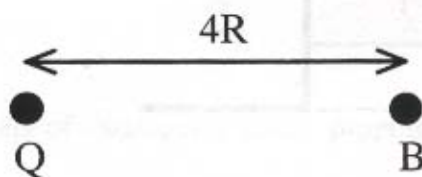
9. If a student runs at a constant speed of 10. m/s on a circular track of radius 240 m, what is the magnitude of his acceleration?

- A.  $0.042 \text{ m/s}^2$
- B.  $0.21 \text{ m/s}^2$
- C.  $0.42 \text{ m/s}^2$
- D.  $2.4 \text{ m/s}^2$

10. A ball is whirled in a horizontal circle of radius  $r$  and speed  $v$ . If the speed is doubled and the radius is cut in half, what will happen to the centripetal force?
- A. It will increase by a factor of 2.
  - B. It will increase by a factor of 4.
  - C. It will increase by a factor of 8.
  - D. It will increase by a factor of 16.
11. What is the frequency of a pendulum with a length of 1.47 m?
- A. 0.411 Hz
  - B. 0.942 Hz
  - C. 1.06 Hz
  - D. 2.43 Hz
12. A mass is oscillating up and down on a spring. If the mass is quadrupled, what will happen to the period?
- A. It will increase by a factor of 2.
  - B. It will increase by a factor of 4.
  - C. It will increase by a factor of 8.
  - D. It will increase by a factor of 16.
13. Astronauts in an orbiting space shuttle experience a sensation of weightlessness. Which of the following statements best explains this phenomenon?
- A. The mass of the shuttle decreases as the distance from Earth increases.
  - B. The shuttle is falling freely toward the Earth.
  - C. The shuttle is moving away from the Earth.
  - D. The shuttle is not affected by Earth's gravity.
14. An imaginary line joining the sun to a planet sweeps out equal areas in equal time intervals. This is a statement of which of the following?
- A. Cavendish's law of universal gravitation
  - B. Galileo's first law of planetary motion
  - C. Kepler's second law of planetary motion
  - D. Newton's third law of motion



15. Which of the following is an accurate description of the gravitational force between two objects?
- A. The force varies directly with the product of the masses of the two objects and inversely with their separation distance.
  - B. The force varies directly with the product of the masses of the two objects and inversely with the square of their separation distance.
  - C. The force varies inversely with the product of the masses of the two objects and directly with their separation distance.
  - D. The force varies inversely with the product of the masses of the two objects and directly with the square of their separation distance.
16. The figure below shows two small charged objects, Q and B, separated by a distance of  $4R$ . Which of the following expressions represents the electric field at point B?

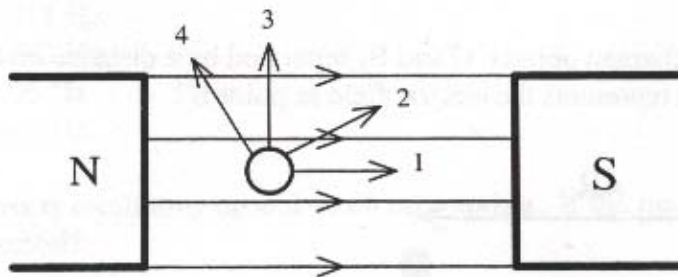


- A.  $E_B = \frac{kQ}{2R^2}$
  - B.  $E_B = \frac{kQ}{4R^2}$
  - C.  $E_B = \frac{kQ}{8R^2}$
  - D.  $E_B = \frac{kQ}{16R^2}$
17. Suppose a magnetic compass is held directly above a straight conductor that is lying horizontally across this page. If electrons flow from left to right through the conductor, to which edge of the page does the North-seeking pole of the compass point?
- A. top
  - B. left
  - C. right
  - D. bottom

18. Which statement best represents a definition of Lenz's law?

- A. A conductor in a magnetic field experiences a force perpendicular to itself and the field.
- B. The magnetic field of an induced current opposes the changing magnetic field causing it.
- C. A current can be induced only when the magnetic field surrounding a conductor is changing.
- D. The potential difference across a conductor is directly proportional to the current through it.

19. The diagram below shows the **cross section** of a wire that is perpendicular to the page and is situated in a uniform magnetic field that is directed to the right. In which of the indicated directions should the wire be moved to induce maximum current?



- A. 1
  - B. 2
  - C. 3
  - D. 4
20. Which principle best explains how motors and generators work?

- A. conduction
- B. induction
- C. resonance
- D. transfer of charge

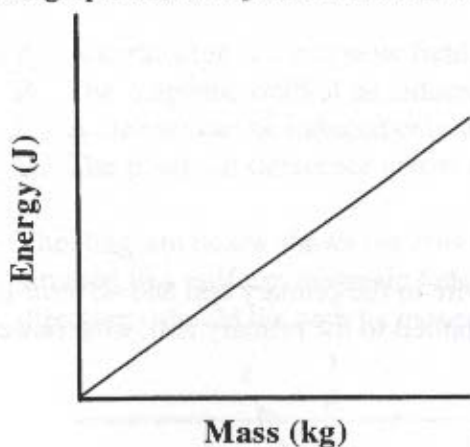
21. A current of 6.0 coulombs of charge flows through a 25 cm length of wire over 1.5 s. The wire runs **parallel** to a 0.10 T external magnetic field. What is the magnitude of the force acting on the wire?

- A. 0 N
- B. 0.080 N
- C. 0.10 N
- D. 8.0 N



22. The current in the armature of an electric motor switches direction with every half rotation. Which part of the motor produces this effect?
- A. armature
  - B. commutator
  - C. iron core
  - D. magnets
23. An ideal transformer (100% efficient) has 20 turns of wire in the primary coil and 40 turns of wire in the secondary coil. If 25.0 watts of power is supplied to the primary coil, what power is developed in the secondary coil?
- A. 5.00 watts
  - B. 12.5 watts
  - C. 25.0 watts
  - D. 50.0 watts
24. What does Bohr's concept of "stationary state" propose regarding electrons?
- A. Electrons will jump from higher energy levels to lower ones without losing energy.
  - B. Electrons will move within orbits without radiating energy.
  - C. Electrons will move in such a way as to escape detection of their position and momentum.
  - D. Electrons will quantize energy when they interact with the hydrogen atom.
25. What does the theory of electromagnetism predict about planetary models of the atom?
- A. Electrons would spiral away from the nucleus.
  - B. Electrons would spiral into the nucleus.
  - C. Negative particles would become neutral.
  - D. Protons would spin out of circular orbit.
26. What is the term that means "the minimum energy required for a photoelectron to escape from a metal plate in a photocell"?
- A. incident frequency
  - B. Planck's constant
  - C. threshold frequency
  - D. work function

27. The graph below represents the relationship between mass and its energy equivalent.



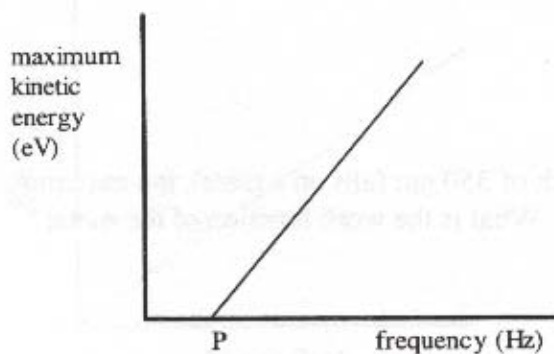
What does the slope of the graph represent?

- A. gravitational field strength
  - B. momentum
  - C. Planck's constant
  - D. the speed of light squared
28. Photon scattering is best explained by which of the following?
- A. Compton effect
  - B. Einstein's theory of special relativity
  - C. Planck's law
  - D. wave theory
29. Which of the following motions would be associated with the **longest** deBroglie wavelength?
- A. a baseball moving at 90 km/hr
  - B. an alpha particle moving at near the speed of light
  - C. an automobile moving at 90 km/hr
  - D. an electron moving at near the speed of light
30. Which model(s) of the nature of light successfully explain(s) the reflection of light?
- A. both the wave model and the particle model
  - B. neither the wave model nor the particle model
  - C. the particle model but not the wave model
  - D. the wave model but not the particle model

31. Which of the following is the **minimum** material necessary to stop beta particles?
- A. air alone
  - B. paper
  - C. plastic sheet
  - D. lead block
32. When electromagnetic radiation with a wavelength of 350 nm falls on a metal, the maximum kinetic energy of the ejected electrons is 1.20 eV. What is the work function of the metal?
- A. 1.3 eV
  - B. 2.3 eV
  - C. 5.4 eV
  - D. 5.7 eV
33. As the frequency of light falling on a metal sheet increases beyond the threshold frequency, the photoelectric effect suggests:
- A. The maximum kinetic energy of the emitted photoelectrons is directly related to the frequency.
  - B. The maximum kinetic energy of the emitted photoelectrons is inversely related to the frequency.
  - C. The maximum kinetic energy of the emitted photoelectrons is directly related to the square of the frequency.
  - D. The maximum kinetic energy of the emitted photoelectrons is inversely related to the square of the frequency.



34. The graph below shows the relationship between the frequency of radiation incident on a photosensitive surface and the maximum kinetic energy of the emitted photoelectrons.



What does the slope of the line represent?

- A. photon escape energy
  - B. Planck's constant
  - C. quantum energy
  - D. work function
35. Threshold frequency is to work function as hertz is to which of the following?
- A. coulomb
  - B. newton
  - C. joule
  - D. watt
36. What is the wavelength of a photon with  $3.2 \times 10^{-19}$  J of energy?
- A. 210 nm
  - B. 420 nm
  - C. 530 nm
  - D. 620 nm
37. The mass defect for a Boron-11 nucleus is  $1.3184 \times 10^{-28}$  kg. What is the binding energy for this nucleus?
- A.  $1.56 \times 10^{-39}$  J
  - B.  $3.96 \times 10^{-20}$  J
  - C.  $1.19 \times 10^{-11}$  J
  - D.  $1.19 \times 10^{-8}$  J

38. Which of the following decay products has the greatest penetrating power?

- A. alpha
- B. beta
- C. gamma
- D. neutron

39.  $^{210}_{84}\text{Po}$  decays by alpha decay. Which of the following is the resulting isotope?

- A.  $^{210}_{85}\text{At}$
- B.  $^{210}_{83}\text{Bi}$
- C.  $^{206}_{82}\text{Pb}$
- D.  $^{206}_{82}\text{Po}$

40. The half-life of radioactive element Y is 65.0 minutes. If the initial mass of a sample of Y is 40.0 g, how much of Y is left after 260. minutes?

- A. 2.50 g
- B. 5.00 g
- C. 10.0 g
- D. 20.0 g

**Constructed Response Questions**

**(Total Value: 50)**

Read each question carefully and write your response in the space provided. Be as neat and organized as possible. Solutions to numerical problems must include:

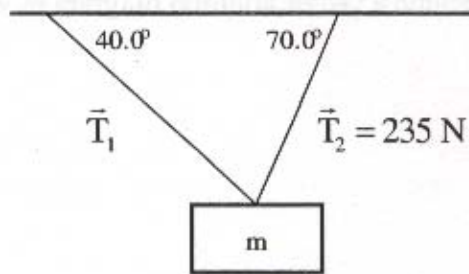
*appropriate formulae*  
*correct substitution of values*  
*final answer clearly indicated*



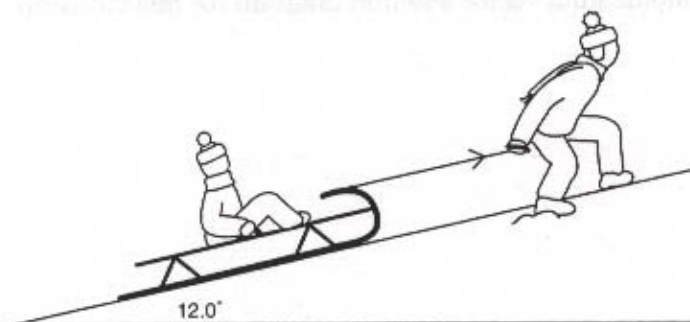
41. Two people pull on a wagon using two separate ropes. One rope exerts a force of  $200.0\text{ N}$ ,  $[\text{E } 7.00^\circ \text{ N}]$ . The other rope applies a force of  $250.0\text{ N}$ ,  $[\text{E } 30.0^\circ \text{ S}]$ . Determine the net force applied to the wagon. Include a vector addition diagram in your solution. **value: 4**



42. The accompanying diagram shows a mass suspended in equilibrium by two ropes. Calculate the mass. **value: 4**



43. A child is being pulled uphill on a toboggan with an acceleration of magnitude  $2.30 \text{ m/s}^2$  by an applied force acting parallel to the incline. The coefficient of kinetic friction is  $0.100$  and the hill is inclined at an angle of  $12.0^\circ$  to the horizontal. If the combined mass of the child and the toboggan is  $35.0 \text{ kg}$ , calculate the magnitude of the force being applied. **value: 5**





44. A red truck with a mass of  $5.00 \times 10^3$  kg traveling East [E] collides with a green truck with a mass of  $3.00 \times 10^3$  kg traveling North [N]. The collision results in the two trucks sticking together and moving off at 16.4 m/s [E  $17.3^\circ$  N].

A) Draw a proper momentum vector addition diagram for this collision.

**value: 2**



B) Calculate the initial speed for each truck. If the posted speed limit was 50.0 km/h, show whether either of the trucks was speeding.

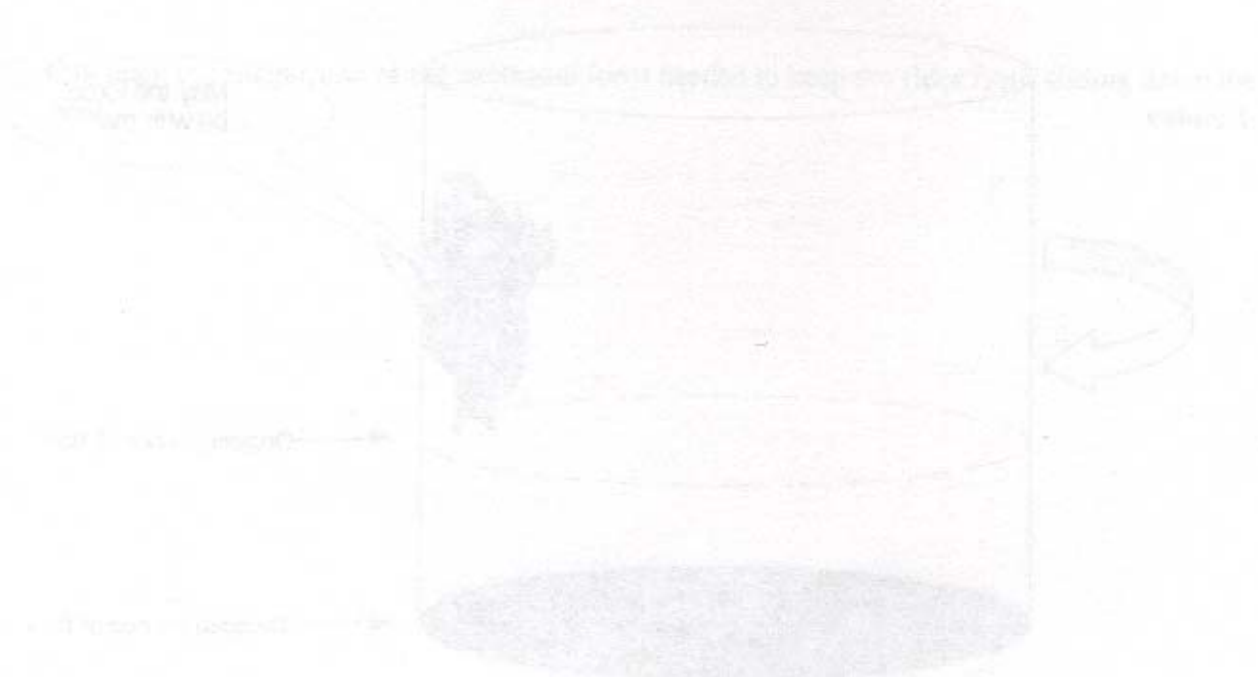
**value: 4**

C) Calculate the amount of kinetic energy lost as a result of the collision.

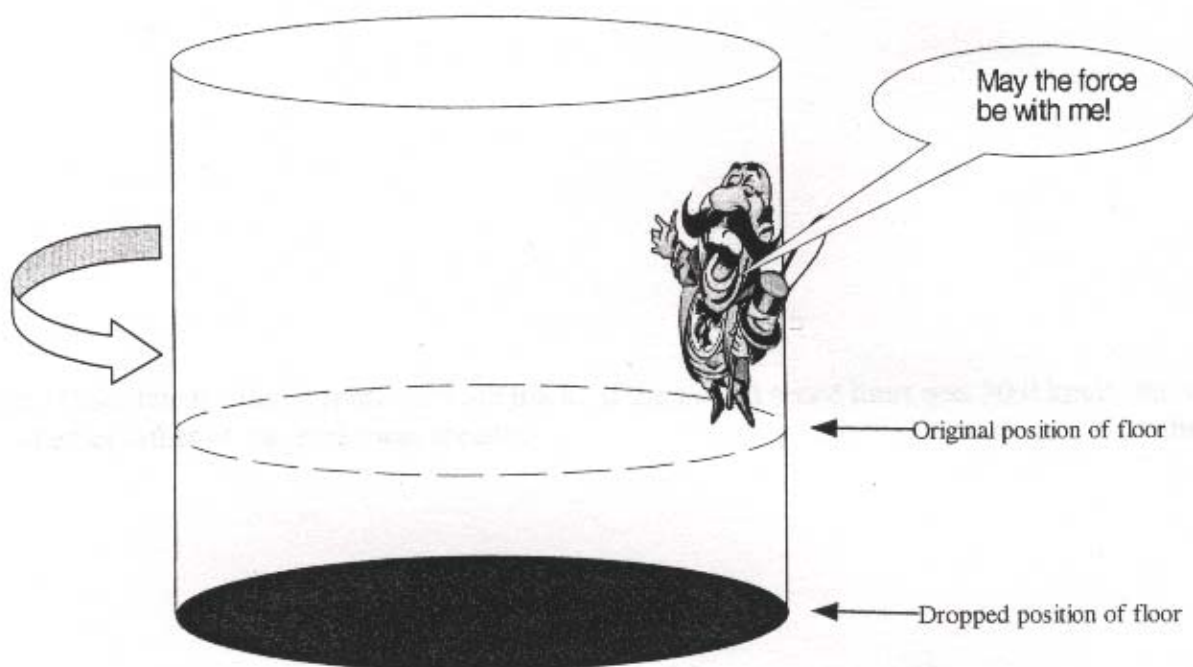
**value: 2**

45. A soccer player kicks the ball in the final seconds of a tie game. Her kick gives the ball a velocity of  $18.1 \text{ m/s}$  at an angle of  $22.5^\circ$  with the level playing field. She is  $16.5 \text{ m}$  from the net. The unguarded net is  $2.42 \text{ m}$  high. In order to score, the ball must go below this height. Assume her aim is good. Using appropriate calculations, determine whether or not the player scores.

**value: 5**



46. The Gravitron is an amusement park ride that consists of a large cylinder rotating around a vertical axis much the same way as a washing machine drum spins. A certain Gravitron of radius 7.00 m is spinning so that the rider has a speed of 17.6 m/s and remains "stuck" to the wall when the floor in the ride is lowered. The diagram below is an illustration of the way this works. The mass of the rider is 75.0 kg.



A) Draw a free body diagram for the forces acting on the rider once the floor has been lowered.

**value: 2**



46. B) In the Gravitron, what force(s) contribute to the centripetal force?

value: 1

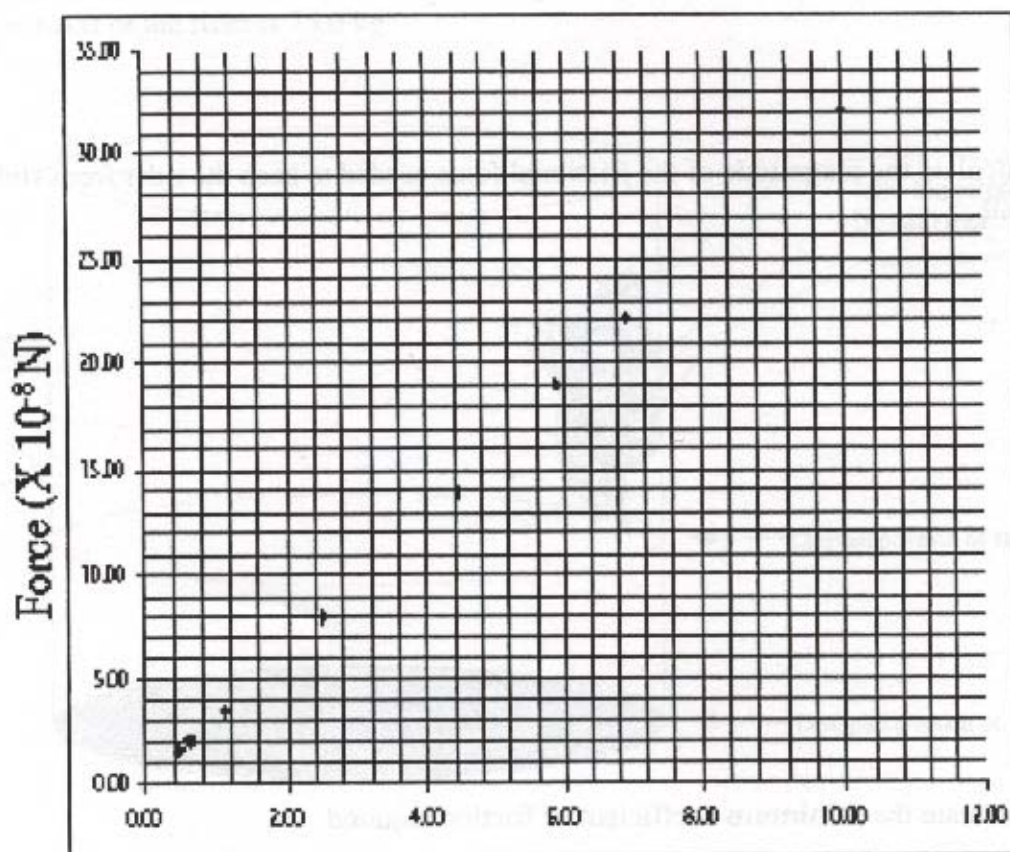
C) Calculate the magnitude of the frictional force needed to keep the rider from sliding down the wall.

value: 1

D) Calculate the **minimum** coefficient of friction required.

value: 2

47.

Force vs  $\frac{1}{r^2}$  $\frac{1}{r^2} (\times 10^3 \text{ m}^{-2})$ 

The above graph of force vs  $1/r^2$  was developed from data obtained by measuring the force of attraction between two identical 700. g masses at various separation distances.

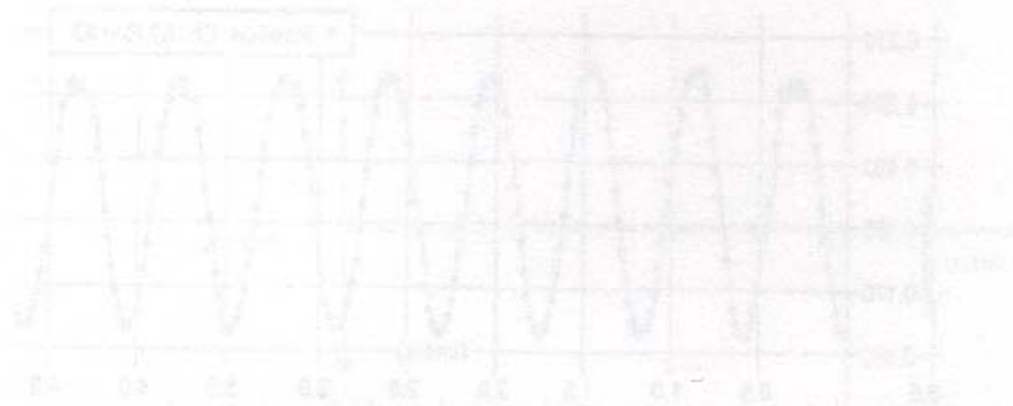
A) Draw the line of best fit.

value: 1

B) Determine the slope of the line of best fit.

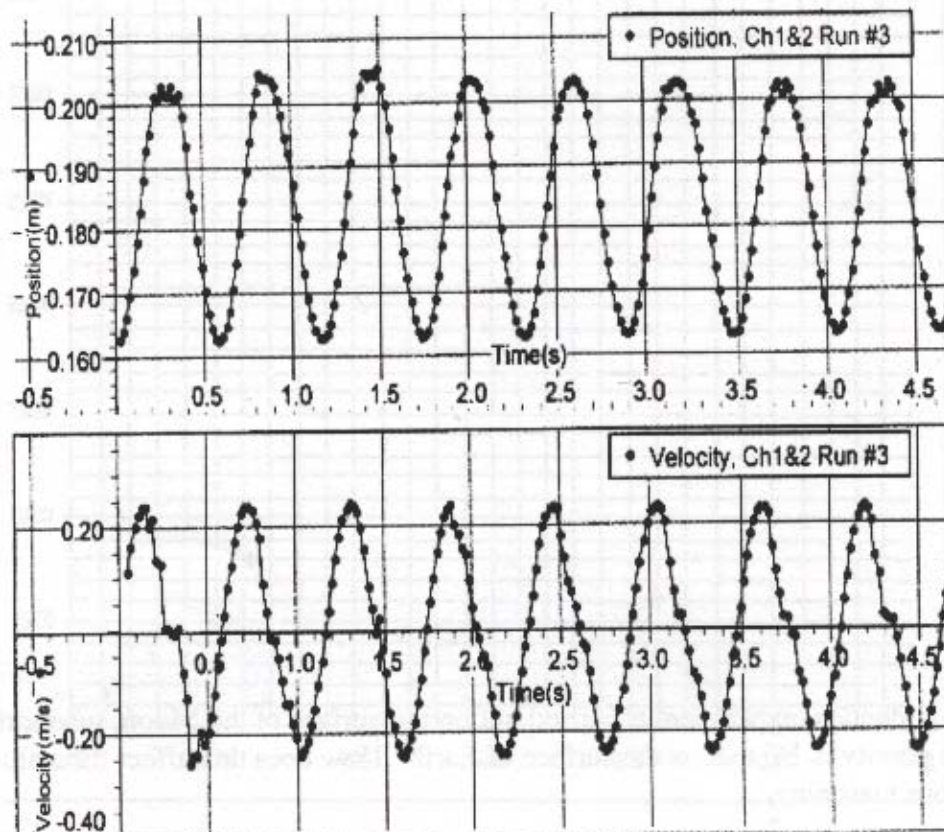
value: 1

47. C) Determine the value of the universal gravitational constant,  $G$ , by using the result from part B) and any other appropriate information. **value: 2**



- D) An identical experiment is carried out on the surface of the Moon, where the acceleration due to gravity is  $1/6$  that on the surface of Earth. How does this affect the value of  $G$ ? Explain your reasoning. **value: 2**

48. The following graphs were obtained by allowing a 300. g mass hanging on a vertical spring to oscillate directly above a motion sensor. Answer the following questions based on the information in the graph.



A) How many oscillations occur in the time interval 0.0 s to 3.5 s?

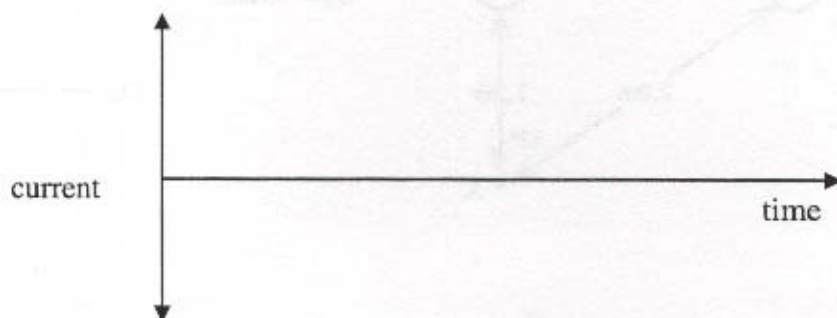
value: 1

B) Calculate the period of oscillation.

value: 1



49. A) A bar magnet is dropped South pole first through a small coil. A current sensor was connected to the coil. On the axes provided, sketch a representation of the current from the time the South pole of the magnet enters the coil to the time the North pole of the magnet exits the coil. **value: 2**



- B) Two long, straight, current-carrying wires are placed so that they are parallel to one another. The picture below shows a cross-sectional view of the two wires. Draw representations of the field lines around both wire A and wire B, and draw force vectors showing the direction of the magnetic force on each wire. **value: 3**



A

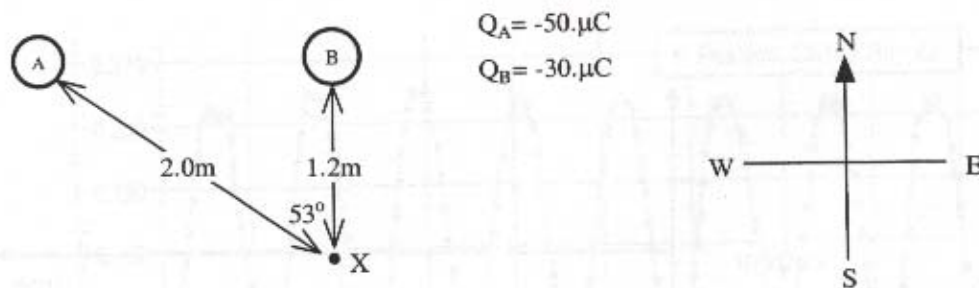


B

The dots in the wires represent the direction of conventional current.

50. In the diagram, A and B represent small spherical charges. Charge A is  $-50. \mu\text{C}$  and charge B is  $-30. \mu\text{C}$ . Calculate the magnitude and direction of the electric field intensity at point X.

value: 5



**Case Study**  
**(Total Value:10)**

This section relates to concepts you learned in Physics 12. Any additional information you require is given.

51. The following information relates to nuclear reactors in use world-wide. Read the material provided and answer the questions that follow. Some of the questions ask you to relate this material to what you have learned in class.

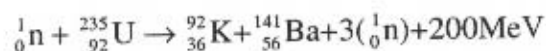
The CANDU reactor was designed by Atomic Energy Canada Limited (AECL) as an alternative to other designs that use enriched uranium having a higher than normal concentration (5%) of U-235. The CANDU system does not require a pressure vessel and can be built in countries where construction technology is limited. It is fueled with pellets of uranium dioxide made from natural uranium (0.7% U-235). The CANDU reactor has considerable redundancy built in, which permits longer operating cycles.

The design consists of a horizontal calandria (container) that has tubes for the fuel rods and cooling heavy water. These tubes are surrounded by more heavy water that acts as a moderator to slow down neutrons. Heavy water is deuterium oxide, D<sub>2</sub>O, in which the hydrogen is an isotope containing a neutron as well as a proton in the nucleus. Since only about 1.5% of all hydrogen atoms are deuterium, a separate plant must be built to separate D<sub>2</sub>O from the more common H<sub>2</sub>O. Because heavy water is a much better moderator than normal water, the cost of producing the heavy water is offset by the lower cost of unenriched fuel.

Like the more common pressurized water reactor, pumps circulate the cooling heavy water through a closed system to a steam generator near the reactor. The moderating heavy water circulates through a separate heat exchange system. The CANDU system uses a vacuum building as additional containment protection. There is also a high degree of computer control, which further protects the reactor.

Because of the need for periodic service shutdowns, multiple reactors are built on a site. There are CANDU reactors in Ontario, Quebec, and New Brunswick.

- A) The fission of uranium in a nuclear reactor takes place according to the following equation:



What characteristic of this reaction leads us to call it a "chain" reaction?

value: 1

- B) In what two ways is heavy water used in a CANDU reactor?

value: 1



51. C) Using the decay equation given above, determine the number of atoms of uranium that would have to decay to generate  $6 \times 10^3$  MeV? **value: 2**

D) People are generally nervous about nuclear reactors. In several paragraphs, identify what you think is the greatest fear people have, and what is the actual degree of risk. **value: 2**

51. E) Proponents of nuclear power often refer to electricity produced by a nuclear reactor as "pollution-free" energy. In about 150 words, evaluate the truth of this statement. Elaborate on a least two separate points in your assessment. **value: 4**