

# NOVA SCOTIA EXAMINATIONS

## PHYSICS 12

**JANUARY 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.**

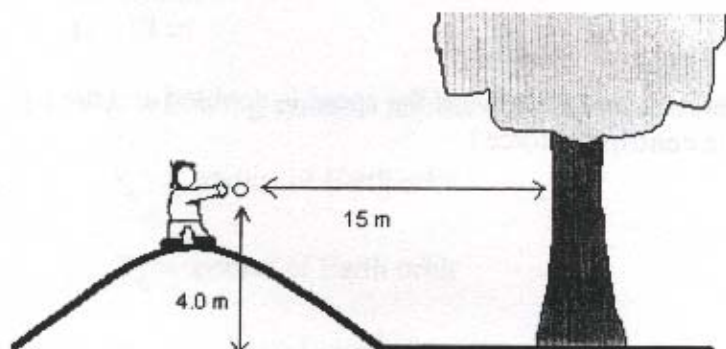
**Please do not turn this page to start until told to do so by the invigilator.**



1. Object X has a mass of 2.00 kg and moves with a velocity of 3.00 m/s, East. Object Y has a mass of 1.75 kg and moves with a velocity of 5.00 m/s, North. The two objects collide and stick together. After the collision, what is the system's direction of motion?
  - A. East of North
  - B. West of North
  - C. East of South
  - D. West of South
2. Two vehicles originally travelling at right angles to each other collide at an intersection. Which of the following statements must be true?
  - A. The total kinetic energy after collision will be the same as the total kinetic energy before collision.
  - B. Both the total momentum and total kinetic energy after collision will be the same as the total momentum and total kinetic energy before collision.
  - C. The total momentum after collision will be the same as the total momentum before collision.
  - D. The total velocity after collision will be the same as the total velocity before collision.
3. Which of the following launch angles will give a projectile maximum range?
  - A.  $30.0^\circ$
  - B.  $45.0^\circ$
  - C.  $60.0^\circ$
  - D.  $90.0^\circ$
4. A 1.0 kg ball is dropped from the roof of a tall building at the same time as a 3.0 kg ball is thrown horizontally from the same height. Which of the following statements is true?
  - A. The 1.0 kg ball hits the ground first because it has no horizontal velocity.
  - B. The 3.0 kg ball hits the ground first because it has more mass.
  - C. The 3.0 kg ball hits the ground first because the force of gravity acting on it is larger.
  - D. Both hit the ground at the same time because they experience the same vertical acceleration.
5. A student standing on top of a building throws a ball with a horizontal velocity of 12 m/s. If the ball strikes the ground 45 m from the base of the building, how high is the building?
  - A. 18 m
  - B. 37 m
  - C. 69 m
  - D. 140 m

The next two questions refer to the following information.

A child standing on a small hill throws a snowball horizontally at a tree that is 15 m away. When the snowball is released, it is 4.0 m above the ground on which the tree stands. The snowball hits the tree 0.60 s after it is released.



6. What was the initial horizontal velocity at which the snowball was thrown?

- A. 2.0 m/s
- B. 6.7 m/s
- C. 9.0 m/s
- D. 25 m/s

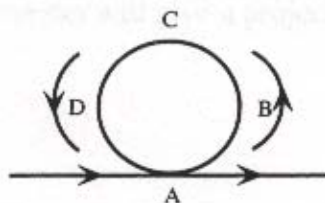
7. Approximately how far above the level ground does the snowball hit the tree?

- A. 1.2 m
- B. 1.8 m
- C. 2.2 m
- D. 4.0 m

8. A mass attached to a string is moving at a constant speed of 2.0 m/s in a horizontal circle of radius 0.50 m. What is the magnitude of the centripetal acceleration of the mass?

- A. 1.0 m/s<sup>2</sup>
- B. 2.0 m/s<sup>2</sup>
- C. 4.0 m/s<sup>2</sup>
- D. 8.0 m/s<sup>2</sup>

9. A student is running at a constant speed on a circular track that has a radius of 135 m. If her acceleration is  $0.60 \text{ m/s}^2$ , what is her speed?
- A. 7.0 m/s
  - B. 9.0 m/s
  - C. 15 m/s
  - D. 81 m/s
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. At an airshow, a pilot takes his aircraft through a complete vertical loop. At which of the following positions will the pilot **feel** heaviest?



- A. at the bottom of the loop
  - B. at the halfway point on the up side of the loop
  - C. at the top of the loop
  - D. at the halfway point on the down side of the loop
12. A 0.100 kg mass is suspended from a spring that has a spring constant of  $0.667 \text{ N/m}$ . If the mass is pulled down and released, what will be the frequency of oscillation?
- A. 0.0616 Hz
  - B. 0.411 Hz
  - C. 0.942 Hz
  - D. 2.43 Hz



13. You are asked to set up a swing using a rope and an old car tire. How long would the rope have to be in order to create a period of oscillation of 4.0 s? (Ignore the radius of the tire.)

- A. 2.0 m
- B. 2.7 m
- C. 4.0 m
- D. 13 m

14. The following symbols refer to Earth orbiting the sun and a comet orbiting the sun.

$r_E$  = radius of Earth orbit

$T_E$  = period of Earth orbit

$r_C$  = radius of comet orbit

$T_C$  = period of comet orbit

How does the value of  $\frac{r_C^3}{T_C^2}$  compare to  $\frac{r_E^3}{T_E^2}$  ?

- A. larger
- B. larger or smaller, depending on the mass of the comet
- C. smaller
- D. the same

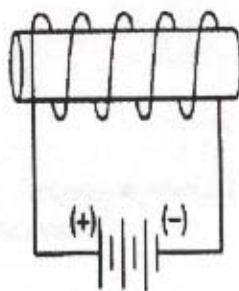
15. Which of the following scientists formulated a mathematical expression to which we now refer as the Law of Universal Gravitation?

- A. Albert Einstein
- B. Galileo Galilei
- C. James Maxwell
- D. Isaac Newton

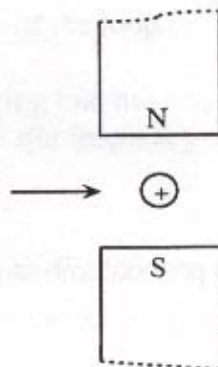
16. Electric field strength is to newtons per coulomb as gravitational field strength is to which of the following:

- A. kilograms per joule
- B. kilograms per newton
- C. newtons per joule
- D. newtons per kilogram

17. Which of the following groups includes three variables that all directly affect the magnitude of the magnetic force experienced by a charged particle in a magnetic field?
- A. the charge on the particle, the speed of the particle, and the magnitude of the field
  - B. the charge, speed, and mass of the particle
  - C. the magnitude of the field, the mass of the particle, and the angle at which the particle enters the field
  - D. the mass of the particle, the speed of the particle, and the strength of the field
18. What is the direction of the magnetic field created inside the coil below?



- A. down
  - B. left
  - C. right
  - D. up
19. In the diagram below, in which direction will the proton shown moving to the right be deflected?



- A. into the page
- B. out of the page
- C. towards the bottom of the page
- D. towards the top of the page

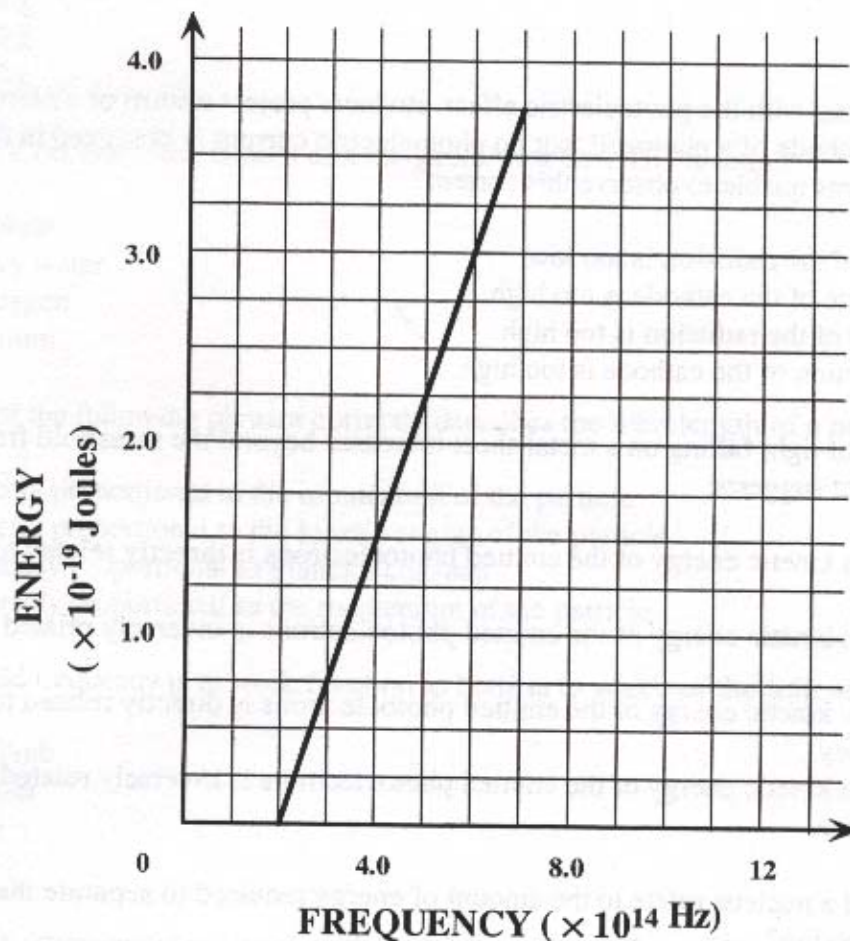


20. Which of the following is the best description of the current leaving a simple DC generator?
- A. It maintains a constant value.
  - B. It varies in direction.
  - C. It increases and decreases once in each revolution of the armature.
  - D. It increases and decreases twice in each revolution of the armature.
21. The hand rule for motors uses the thumb, the fingers, and the palm to represent various properties. What does the thumb represent?
- A. The direction of the applied force.
  - B. The direction of the current.
  - C. The direction of the magnetic field.
  - D. The direction of the magnetic force.
22. A step-down transformer has 100 turns on its primary coil and 25 turns on its secondary coil. When the transformer operates, a 3.50 A current and a 117 V potential difference are measured in the primary. What is the potential difference in the secondary coil?
- A. 29.3 V
  - B. 33.4 V
  - C. 117 V
  - D. 468 V
23. A direct current source is used to operate an electric motor. Which of the following statements best explains what happens at each half rotation of the split ring commutator?
- A. The current increases in the armature.
  - B. The direction of the current in the armature reverses.
  - C. The polarity of the field magnets reverses.
  - D. The strength of the field magnets increases.
24. If an electron orbiting an atomic nucleus moves to a lower energy level, which of the following describes what will happen to the energy of the atom?
- A. cannot be determined
  - B. decreases
  - C. increases
  - D. remains the same

25. Which of the following phenomena is the best evidence for energy quanta in the hydrogen atom?
- A. alpha particle scattering
  - B. emission spectra
  - C. radioactive decay
  - D. the photoelectric effect
26. Bohr's concept of energy levels states that:
- A. electrons all have the same kinetic energy
  - B. electrons can jump from one orbit to another without changing energy
  - C. electrons can remain in one orbit without radiating energy
  - D. electrons orbit in such a way as to escape detection of their position and momentum
27. The Compton Effect describes which of the following phenomena?
- A. photon absorption
  - B. photon emission
  - C. photon scattering
  - D. photon transfer
28. If an electron has a kinetic energy of  $2.366 \times 10^{-18}$  J, what is its deBroglie wavelength?
- A.  $2.80 \times 10^{-16}$  m
  - B.  $4.37 \times 10^{-14}$  m
  - C.  $1.74 \times 10^{-13}$  m
  - D.  $3.19 \times 10^{-10}$  m
29. Which model of the nature of light successfully explains the photoelectric effect?
- A. both the wave model and the particle model
  - B. neither the wave model nor the particle model
  - C. particle model but not wave model
  - D. wave model but not particle model

The graph below should be used for the next two (2) questions.

Students did an experiment to find the value of Planck's constant. They plotted a graph showing the maximum kinetic energy of electrons ejected from a metal versus the frequency of the incident photons.



30. Referring to the graph, which of the following statements is true?

- A. The difference between the maximum and minimum X values is the threshold frequency of the metal used.
- B. The slope of the graph represents the threshold frequency of the metal used.
- C. The X intercept represents the threshold frequency of the metal used.
- D. The Y intercept represents the threshold frequency of the metal used.



31. Based on the students' graph, what is the best estimate of Planck's constant?
- A.  $5.6 \times 10^{-34}$  J-s
  - B.  $6.0 \times 10^{-34}$  J-s
  - C.  $7.2 \times 10^{-34}$  J-s
  - D.  $7.5 \times 10^{-34}$  J-s
32. While experimenting with the photoelectric effect, students project a form of electromagnetic radiation on the cathode of a photocell, but no photoelectric current is observed in the circuit. Why are the students unable to observe this current?
- A. The intensity of the radiation is too low.
  - B. The temperature of the cathode is too high.
  - C. The frequency of the radiation is too high.
  - D. The work function of the cathode is too high.
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. Binding energy of a nucleus refers to the amount of energy required to separate the nucleus into which of the following?
- A. individual electrons
  - B. individual nucleons
  - C. individual neutrons
  - D. individual protons
35. What common elementary particles are contained in the nucleus of the radioisotope  $^{239}_{92}\text{U}$ ?
- A. 92 protons and 239 neutrons
  - B. 92 protons and 147 neutrons
  - C. 239 protons and 92 neutrons
  - D. 147 protons and 331 neutrons

36. The half life of  $^{90}_{38}\text{Sr}$  is 28 years. If 60.0 g of this isotope is found in a sample, what mass will be found in the same sample 56 years later?
- A. 3.75 g
  - B. 7.50 g
  - C. 15.0 g
  - D. 30.0 g
37. Which of the following is used as a moderator in a CANDU reactor?
- A. graphite
  - B. heavy water
  - C. hydrogen
  - D. uranium
38. Which of the following phrases correctly describes the wavelength of a particle?
- A. directly proportional to the momentum of the particle
  - B. directly proportional to the kinetic energy of the particle
  - C. inversely proportional to Planck's constant
  - D. inversely proportional to the momentum of the particle
39. Threshold frequency is to work function as hertz is to which of the following?
- A. coulomb
  - B. newton
  - C. joule
  - D. watt
40. 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 the work function of the metal?
- A. 1.3 eV
  - B. 2.4 eV
  - C. 5.4 eV
  - D. 5.7 eV

**Constructed Response Questions**

(Total Value: 50)

Read each question carefully and write your response in the space provided. Be as neat and organized as you can in order to get maximum credit for method.

Solutions to numerical problems must include:

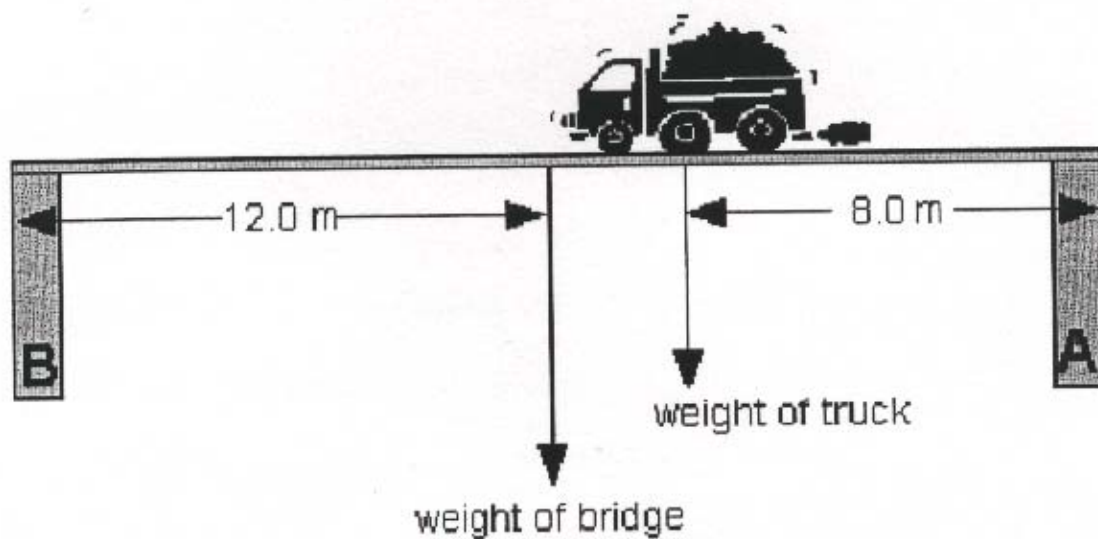
- ✓ *appropriate formulae*
- ✓ *correct substitution of values*
- ✓ *final answer, with units, clearly indicated*



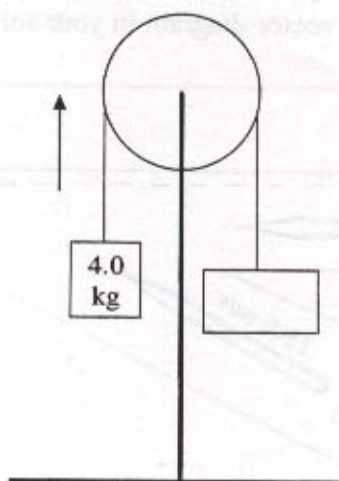
41. The driver of a motor boat points it directly toward the opposite bank of a 52 m wide river. The velocity of the boat relative to the water is 4.0 m/s North, and the river flows at 3.2 m/s East. When the boat reaches the opposite riverbank, what is the displacement from its point of departure? Include a vector diagram in your solution. **value: 4**



42. A  $2.00 \times 10^4$  kg dumptruck is stopped one third of the way across a 24.0 m long bridge that is supported at each end by a concrete pillar. If the bridge is of uniform construction and has a mass of  $1.25 \times 10^5$  kg, what are the supporting forces that both pillars must provide? **value: 4**



43. In the system shown below, the 4.0 kg mass is accelerating upwards at  $2.0 \text{ m/s}^2$ . Assume the string is massless and the pulley is frictionless.

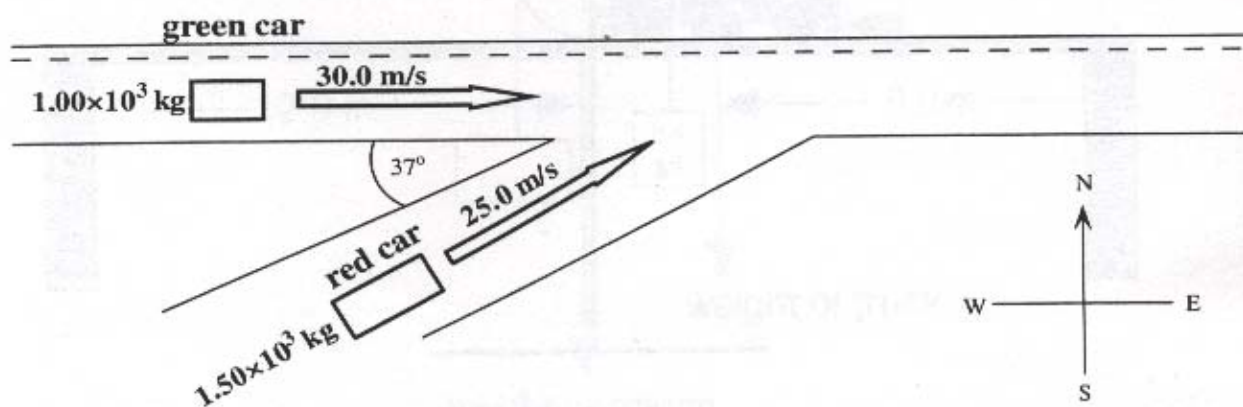


Determine the unknown mass and the tension in the cord.

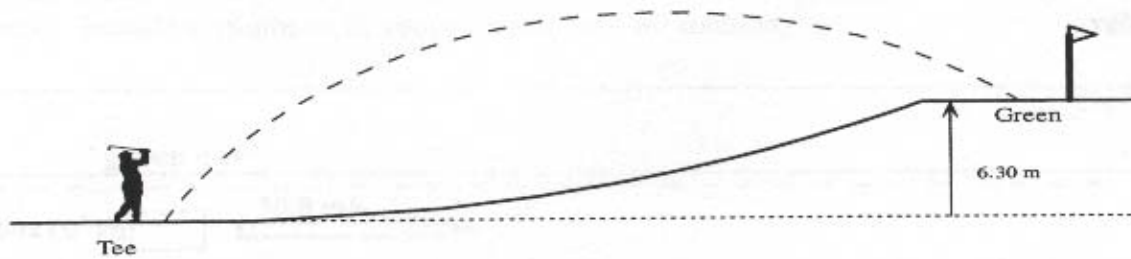
value: 5



44. A red car having a mass of  $1.50 \times 10^3$  kg was coming onto the highway from a ramp at a velocity of  $25.0$  m/s  $[E 37.0^\circ N]$ . It struck a green car having a mass of  $1.00 \times 10^3$  kg that was traveling East on the highway at a speed of  $30.0$  m/s. Immediately after the collision, the velocity of the green car was  $24.1$  m/s  $[E 32.6^\circ N]$ . Determine the velocity of the red car immediately after the collision. Include a momentum vector diagram in your solution. **value: 8**



45. A golfer hits the ball off the tee with an initial velocity of  $40.0 \text{ m/s}$  at  $40.0^\circ$  from the horizontal. The ball comes down on a green that is  $6.30 \text{ m}$  higher than the tee as shown in the diagram. Calculate the horizontal distance from the tee to the point where the ball first lands. **value: 5**



46. Spiderman has a mass of 80.0 kg. He swings in a circular arc on a web that is 4.00 m long.

A) Draw a free body diagram of the forces acting on Spiderman at the bottom of the swing.

**value: 1**

B) If his speed is 3.20 m/s at the bottom of the swing, what is the tension in the web? **value: 3**

C) If the maximum tension the web can withstand is 1800. N, what is the minimum speed Spiderman would have to have at the bottom in order to break the web? **value: 2**



47. A) Two spheres, each having a mass of 40.0 kg, are positioned so that their centres are 8.00 m apart. What is the gravitational force of attraction between the two spheres? **value: 2**

B) If the mass of one of the spheres in the previous question was doubled, how far apart would the spheres have to be placed to maintain the same force of gravity?

**value: 2**

C) On a popular science TV show, the host described the orbiting space shuttle astronauts as being "weightless" because they are in a "zero gravity" environment.

i) Using field concepts, explain why the phrase "zero gravity" **should not** be used. **value: 1**

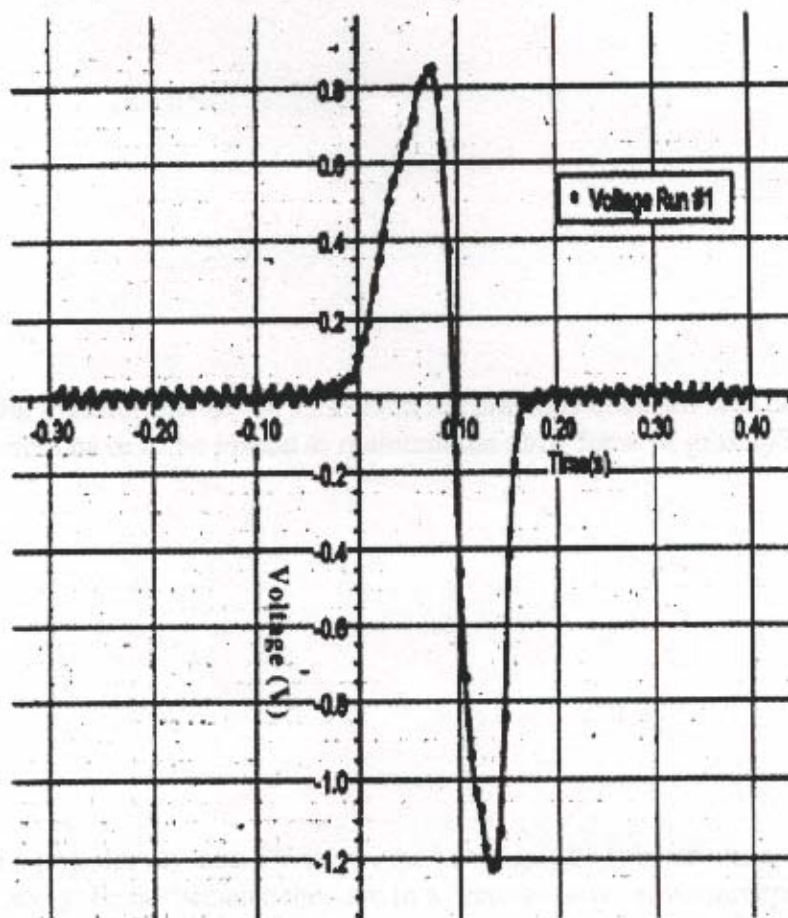
ii) Explain why the astronauts **feel** weightless.

**value: 1**

48. A mass oscillates at the end of a vertically mounted spring with a period of 0.12 s. If you exactly tripled the mass, what would the new period be? **value: 2**

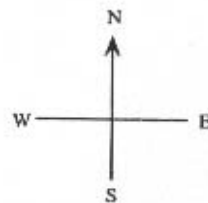
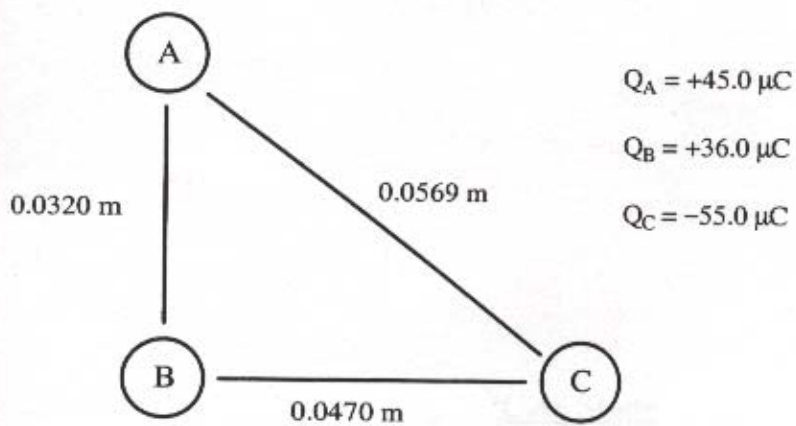


49. The following graph of voltage vs time was produced by dropping a bar magnet North pole first through a conducting loop. A voltage sensor was connected to the coil.



- A) Why are there both positive and negative peaks on the graph? **value: 1**
- B) What could account for the second peak being of greater magnitude than the first? **value: 2**
- C) Sketch below what the graph would look like if the magnet were dropped South pole first. **value: 2**

50. Determine the net force on charged particle B in the diagram below. Include a vector diagram in your solution. **value: 5**





To confirm the theory that there had been a natural nuclear reactor, scientists looked for other evidence. They looked for a material that would be produced in a nuclear reactor, but not anywhere else. The concentration of neodymium at the site nearly matched the concentration in the spent fuel of modern reactors. This could only have happened if there had been a nuclear reaction. There is even evidence that the Oklo reactors bred their own fuel by bombarding U-238 with neutrons and producing easily fissionable plutonium.

These reactors were clearly the result of naturally-occurring phenomena, and remained active for 250 000 years.

*Adapted from August 1976 Scientific American article.*



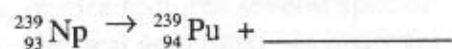
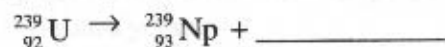
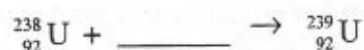
51.

A) What three components are necessary for a nuclear reactor to operate?

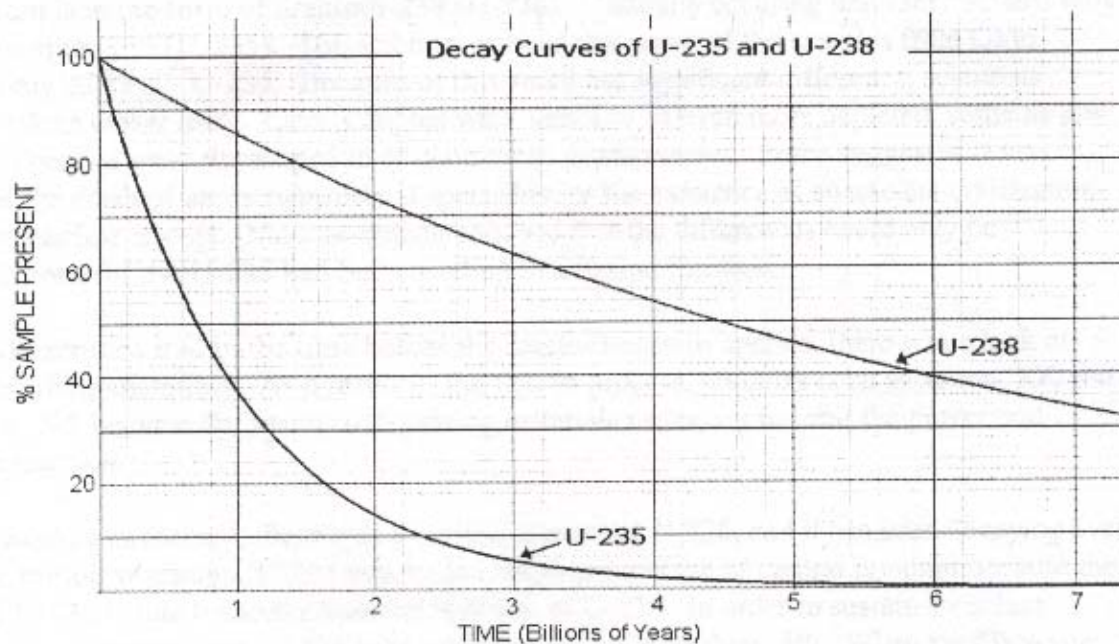
value: 1

B) Complete the following decay chain, which outlines the progression from Uranium-238 to Uranium-235.

value: 2



C)



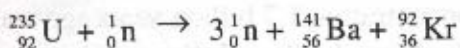
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- i) Based upon the graphs the half-life of uranium-235 is \_\_\_\_\_ billion years and the half-life of uranium-238 is \_\_\_\_\_ billion years **value: 1**
- ii) The fuel concentration 1.7 billion years ago was sufficient to sustain a nuclear reaction. Explain why the **relative** uranium isotope concentration has changed to the extent that a reaction can no longer proceed. **value: 1**

- D) What part of a modern nuclear reactor serves the same function as the xenon and neodymium did in the Oklo reactor? **value: 1**

51.

- E) During the  $3.00 \times 10^5$  years that the Oklo reactor was operating,  $6.00 \times 10^3$  kg of uranium-235 was consumed. The fission reaction of uranium-235 is:



Calculate the amount of energy, in Joules, that would have been produced per atom of U-235. The masses of the reactants and products in the fission reaction are given below.

$${}_{92}^{235}\text{U} = 235.044 \text{ u}$$

$${}_0^1\text{n} = 1.009 \text{ u}$$

$${}_{56}^{141}\text{Ba} = 140.883 \text{ u}$$

$${}_{36}^{92}\text{Kr} = 91.905 \text{ u}$$

**value: 4**