# SRI LANKAN PHYSICS OLYMPIAD COMPETITION – 2010

Time Allocated : 02 Hours
Calculators are not allowed to use.

---

Date of Examination : 10 – 07 – 2010        Index No. : ………………

Time : 9.00 a.m. - 11.00 a.m.

---

## INSTRUCTIONS

- Answer all questions
- There are two parts (A and B) in this paper.
- Part A contains 20 multiple choice questions. Your answer to each question must be marked on the body of the question paper itself.
- Select the single answer that provides the best response to each question. Please be sure to use a pencil and underline the response corresponding to your choice. If you change the choice of an answer, the previous underline mark must be completely erased.
- Your score on this multiple choice section will be your number of correct answers. There is no penalty for guessing. It is to your advantage to answer every question.

- Part B contains three questions.
- Use the paper provided to do all the calculations in part A as well as in part B.
- Write down the corresponding final expressions for part B questions on the last page attached in the question paper.
- At the end of the exam, handover the question paper with your marked responses together with the final answer sheet.
- Handover the papers used to workout the problems in Part B separately with your index number written on each paper.
- Do not detach any sheet from the question paper.

$g = 10\ m\ s^{-2}$

PART A

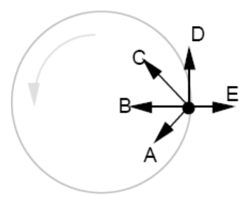
1. Which of the following is not associated with a sound wave?

(1) amplitude (2) period (3) polarization (4) velocity (5) wavelength

2. An object shown in the figure performs uniform circular motion. Which arrow best depicts the net force acting on the object at the instant shown?

(1) A (2) B (3) C (4) D

(5) E




3. What temperature change on the Kelvin scale is equivalent to a 10 degree change on the Celsius scale?

(1) 283 K (2) 273 K (3) 18 K (4) 10 K (5) 0

4. The "reaction" force does not cancel the "action" force because

(1) The action force is greater than the reaction force.

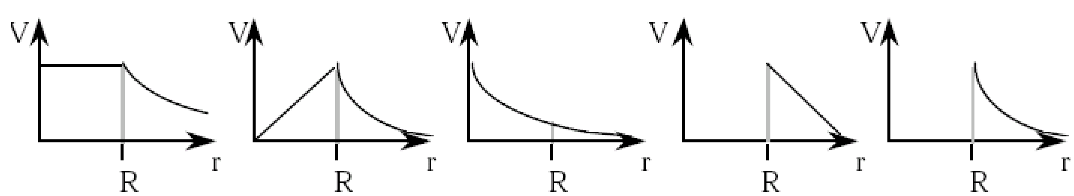
(2) The action force is less than the reaction force.

(3) They do not act on the same body.

(4) They are in the same direction.

(5) The reaction exists only after the action force is removed.

5. An isolated conducting sphere of radius $R$ has a charge $+Q$. Which graph best represents the electric potential (V) as a function of $r$, the distance from the center of the sphere?




(1) (2) (3) (4) (5)

6. The principle underlying fiber optics is

(1) diffraction (2) dispersion (3) interference (4) polarization

(5) total internal reflection

7. The period of a spring-mass system undergoing simple harmonic motion is *T*. If the amplitude of the spring-mass system's motion is doubled, the period will be

(1) (1/4)$T$ (2) (1/2)$T$ (3) $T$ (4) 2$T$ (5) 4$T$

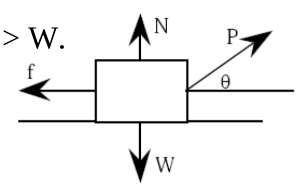
8. A radioactive element has a half-life of 4.0 hours. Approximately how much of the radioactive element will remain after 12.0 hours?

(1) 1/16 (2) 1/8 (3) 1/6 (4) 1/4 (5) 1/3

9. A student pulls a wooden box along a rough horizontal surface at constant speed by means of a force (P) as shown to the right. Which of the following must be true?

(1) P > f and N < W. (2) P > f and N = W. (3) P = f and N > W.

(4) P = f and N = W. (5) P < f and N = W.



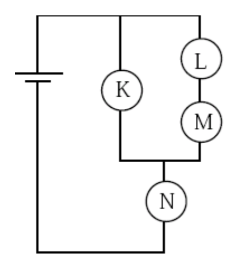

10. Four identical light bulbs K, L, M, and N are connected in the electrical circuit shown in the figure. Bulb K burns out. Which of the following statements is true?

(1) All the light bulbs go out. (2) Only bulb N goes out.

(3) Bulb N becomes brighter.

(4) The brightness of bulb N remains the same.

(5) Bulb N becomes dimmer but does not go out.

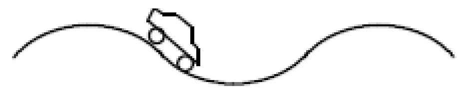



11. A positively charged conductor attracts a second object. Which of the following statements *could* be true?

I. The second object is a conductor with negative net charge.
II. The second object is a conductor with zero net charge.
III. The second object is an insulator with zero net charge.

(1) I only (2) II only (3) III only (4) I & II only (5) All I, II & III

12. A car is traveling on a road in hilly terrain as shown in the figure. Assume the car has speed $v$ and the tops and bottoms of the hills have radius of curvature $R$. The driver of the car is most likely to feel weightless



(1) at the top of a hill when $v > \sqrt{gR}$ .

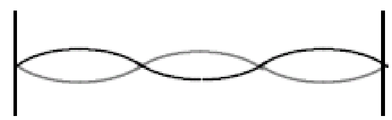
(2) at the bottom of a hill when $v > \sqrt{gR}$ .

(3) going down a hill when $v = \sqrt{gR}$

(4) at the top of a hill when $v < \sqrt{gR}$ .

(5) at the bottom of a hill when $v < \sqrt{gR}$ .

13. A string is firmly attached at both ends to two vertical walls. When a frequency of 60 Hz is applied, the string vibrates in a standing wave pattern as shown in the figure. If the tension in the string and its mass per unit length do not change, which of the following frequency could *NOT* produce a standing wave pattern in the string?



(1) 30 Hz (2) 40 Hz (3) 80 Hz

(4) 100 Hz (5) 180 Hz

14. A magnet is dropped through a vertical copper pipe slightly larger than the magnet. Relative to the speed it would fall in air, the magnet in the pipe falls

(1) more slowly because it is attracted by the innate magnetic field of the pipe.

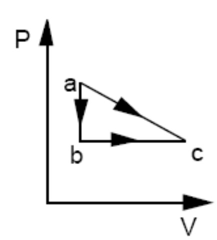
(2) more slowly because the currents induced in the pipe produce an opposing magnetic field.

(3) at the same rate.

(4) more quickly because it is attracted by the innate magnetic field of the pipe.

(5) more quickly because the currents induced in the pipe produce a opposing magnetic field.

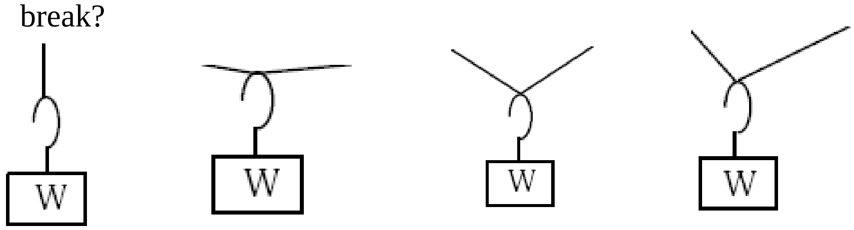
15. An ideal gas can be taken from state $a$ to $c$ by two different processes, $a \rightarrow c$ or $a \rightarrow b \rightarrow c$. During the direct process $a \rightarrow c$, 20.0 J of work is done by the system and 30.0 J of heat is added to the system. During the process $a \rightarrow b \rightarrow c$, 25.0 J of heat is added to the system. How much work is done by the system during $a \rightarrow b \rightarrow c$?




(1) 5.0 J (2) 10.0 J (3) 15.0 J

(4) 20.0 J (5) 25.0 J

16. Assume the objects in the following diagrams have equal mass and the strings holding them in place are identical. In which case would the string be most likely to break?




All would be equally likely to break

(1) (2) (3) (4) (5)

17. A proton of mass $M$ and kinetic energy $E_k$ passes undeflected through a region with electric and magnetic fields perpendicular to each other. The electric field intensity has magnitude $E$. The magnitude of the magnetic flux density $B$ is given by

(1) $\sqrt{\frac{ME^2}{E_k}}$ (2) $\sqrt{\frac{ME}{2E_k}}$ (3) $\sqrt{\frac{2ME^2}{E_k}}$ (4) $\sqrt{\frac{ME^2}{2E_k}}$ (5) $\sqrt{\frac{ME^2}{E_k^2}}$

18. If the Earth were to stop rotating, but not change shape,

(1) the weight of an object at the equator would increase.

(2) the weight of an object at the equator would decrease.

(3) the weight of an object at the north pole would increase.

(4) the weight of an object at the north pole would decrease.

(5) all objects on Earth would become weightless.

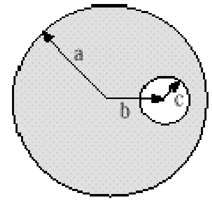
19. The following equation is an example of what kind of nuclear reaction?

$$^{12}_{6}\text{C} + {}^{4}_{2}\text{He} \rightarrow {}^{16}_{8}\text{O} + \text{Energy}$$

(1) fission (2) fusion (3) alpha decay (4) beta decay

(5) positron decay

20. A non conducting sphere of radius $a$ has uniform charge density $\rho$. A spherical cavity of radius $c$ is formed in the sphere. The cavity is centered a distance $b$ ($b > c$) from the center of the sphere.



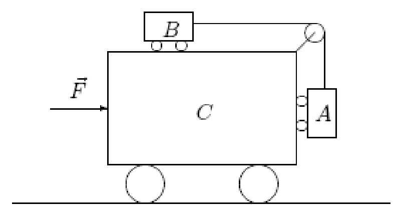

The magnitude of the electric field intensity anywhere inside the cavity is given by

(1) $\dfrac{\rho b}{3\varepsilon_o}$ (2) $\dfrac{\rho a^3}{3\varepsilon_o b^2}$ (3) $\dfrac{\rho\left(a^3 - c^3\right)}{3\varepsilon_o b^2}$ (4) $\dfrac{\rho\left(b - \dfrac{c^3}{2b^2}\right)}{3\varepsilon_o}$

(5) $\dfrac{\rho\left(b - \dfrac{c^3}{b^2}\right)}{3\varepsilon_o}$

**PART B**

(1) Figure shows a mechanical system consisting of three carts *A*, *B* and *C* of masses $m_1$, $m_2$ and $m_3$ respectively. Carts *B* and *A* are connected by a light taut inelastic string which passes over a light smooth pulley attached to the cart *C* as shown. Neglect all frictional forces, the moments of inertia of the pulley and of the wheels of all three carts.




(i) A horizontal force *F* is now applied to cart *C* as shown. The magnitude of *F* is such that carts *A* and *B* remain at rest relative to cart *C*.

(a) Derive an expression for the tension (*T*) in the string connecting carts *A* and *B*.

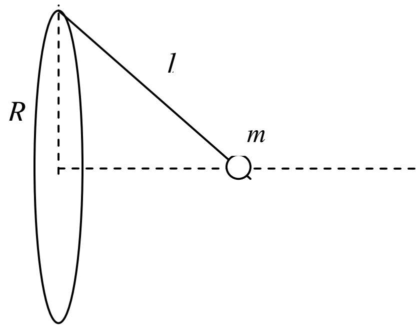
(b) Obtain an expression for the magnitude of *F*.

(ii) Then the cart *C* is held stationary, while carts *A* and *B* are released from rest.

(a) Derive an expression for the acceleration (*a*) of carts *A* and *B*.

(b) Obtain an expression for the tension (*T*) in the string.

(2) A small charged ball of mass $m$ and charge $q$ is suspended from the highest point of a ring of radius $R$ by means of an insulating cord of negligible mass. The ring is made of a rigid wire of negligible cross section and lies in a vertical plane. A charge $Q$ of the same sign as $q$ is uniformly distributed on the ring. Derive an expression for the length $l$ of the cord in terms of $Q$, $q$, $R$, $m$, $g$ and $\varepsilon_0$ so that the equilibrium position of the ball lies on the symmetry axis perpendicular to the plane of the ring as shown in the figure.




(3) An electron gun $T$ emits electrons accelerated by a potential difference $V$ in a vacuum in the direction of the line $a$ as shown in figure. The target $M$ is placed at a distance $d$ from the electron gun in such a way that the angle between the line segment connecting the points $T$ and $M$ and the line $a$ is $\alpha$ as shown in the figure. A uniform magnetic field is directed into the paper and perpendicular to it. Obtain an expression for the magnitude of the magnetic flux density $B$ in terms of $m$ (mass of the electron), $e$ (charge of the electron), $V$, $d$, and $\alpha$ so that the electrons hit the target $M$.