SRI LANKAN PHYSICS OLYMPIAD COMPETITION – 2007

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

Date of Examination : 07 – 07 – 2007   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 a single response that provides the best answer 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 underlined 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 (03) semi – structured type 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 or the final numerical answers for part B questions on the last page attached in the question paper itself.
- 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.

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

PART A

(1) A constant horizontal force of magnitude 100N acts on a 5 kg mass placed on a smooth horizontal table. If the mass starts from rest what will its velocity be after 3 s?

(1) 60 m s^{-1} in the direction of the force

(2) 60 m s^{-1} opposite the direction of the force

(3) 180 m s^{-1} perpendicular to the direction of the force

(4) 90 m s^{-1} in the direction of the force

(5) 90 m s^{-1} opposite the direction of the force

(2) A ball is dropped from a rooftop a height h above the ground. If air resistance is ignored how long does it take to hit the ground?

(1) $\frac{1}{2}gh$

(2) gh

(3) $\sqrt{2gh}$

(4) $\sqrt{\frac{2h}{g}}$

(5) $\frac{2h}{g}$

(3) A box of mass 5 kg rests on a horizontal table. The coefficient of static friction between the box and the table is 0.3. When the box is pulled with a horizontal force of 10 N, it does not move. The force of friction exerted by the table on the box is

(1) 15 N

(2) 12 N

(3) 10 N

(4) 5 N

(5) 3 N

(4) A cork of density 0.5×10^3 kg m^{-3} floats in water. Percentage of the volume of the cork submerged is (density of water is 10^3 kg m^{-3})

(1) 90%.

(2) 80%.

(3) 70%.

(4) 60%

(5) 50%.

(5) A mass attached to one end of a light spring executes simple harmonic motion about equilibrium position with amplitude A. Its speed as it passes through the equilibrium position is v. If extended to $2A$ and released, the speed of the mass passing through the equilibrium position will be (Neglect all the external forces acting on the mass)

(1) $\frac{v}{4}$

(2) $\frac{v}{2}$

(3) v

(4) $2v$

(5) $4v$

(6) An asteroid orbits the Sun. At its farthest point (aphelion) it is at a distance $2R$ from the Sun and moving at a speed v. At its closest point of approach (perihelion) it is a distance R from the Sun. The speed of the asteroid at the perihelion is

(1) $\frac{v}{4}$

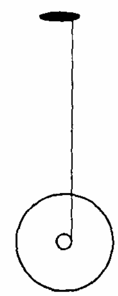
(2) $\frac{v}{2}$

(3) v

(4) $2v$

(5) $4v$

(7) As shown in the figure a yo-yo is released from hand with the string wrapped around the finger. If the hand is held still, the direction and magnitude of the acceleration of the yo-yo is



(1) downward, less than g.

(2) upward, less than g.

(3) downward, g.

(4) upward, greater than g.

(5) downward, greater than g.

(8) A particle of mass $2m$ collides with a particle of mass m at rest. If the particles stick together after the collision, what fraction of the initial kinetic energy is lost in the collision?

(1) 0

(2) $\frac{1}{4}$

(3) $\frac{1}{3}$

(4) $\frac{1}{2}$

(5) $\frac{2}{3}$

(9) An ideal gas expands to twice its volume. If the process is isothermal, the work done by the gas is W_i . If the process is adiabatic, the work done by the gas is W_a . Which of the following is true?

(1) $W_i = W_a$

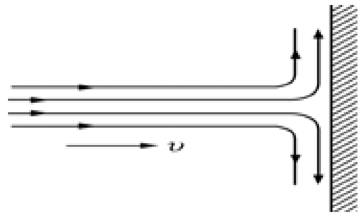
(2) $0 = W_i < W_a$

(3) $0 < W_i < W_a$

(4) $0 = W_a < W_i$

(5) $0 < W_a < W_i$

(10) A stream of water of density ρ, cross-sectional area A, and speed v strikes a wall that is perpendicular to the direction of the stream, as shown in the figure below. The water then flows sideways across the wall. The force exerted by the stream on the wall is



(1) $\frac{\rho v A}{2}$

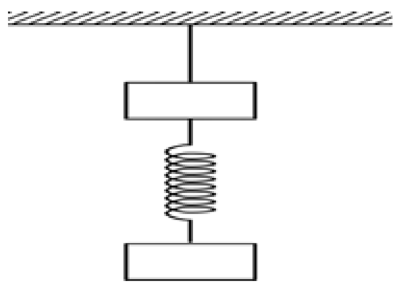
(2) $\rho v^2 A$

(3) $\rho g h A$

(4) $\frac{v^2 A}{\rho}$

(5) $\frac{v^2 A}{2\rho}$

(11) Two identical blocks are connected by a light spring. The combination is suspended, at rest, from a string attached to the ceiling, as shown in the figure below. The string breaks suddenly. Immediately after the string breaks, what is the downward acceleration of the upper block?



(1) 0

(2) $g/2$

(3) g

(4) $2/g$

(5) $2g$

(12) One end of a nichrome wire of length $2L$ and cross-sectional area A is attached to an end of another nichrome wire of length L and cross-sectional area $2A$. If the free end of the longer wire is at an electric potential of 8.0 V, and the free end of the shorter wire is at an electric potential of 1.0 V, the potential at the junction of the two wires is equal to

(1) 2.4 V

(2) 3.3 V

(3) 4.5 V

(4) 5.7 V

(5) 6.6 V

(13) Which one of the following has the most energy?

(1) an ultra-violet photon

(2) an X-ray photon

(3) a photon of visible light

(4) an infrared photon

(5) a radio photon

(14) In an electromagnetic wave moving through the vacuum,

(1) the electric and magnetic fields are perpendicular to each other and to the direction of propagation.

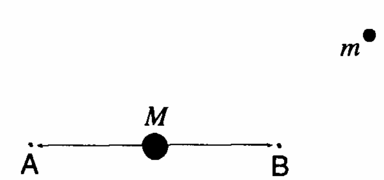
(2) the electric and magnetic fields are perpendicular to each other and parallel to the direction of propagation.

(3) the electric and magnetic fields are parallel to each other and along the direction of propagation.

(4) the electric field is along the direction of propagation and the magnetic field perpendicular to it.

(5) the magnetic field is along the direction of propagation and the electric field is perpendicular to it.

(15) A small mass *m* is moved from where it is on the figure to either positions *A* or *B*, which are equidistant from a large mass *M*. Mass *m* starts at rest and ends at rest. Which of the following is true regarding the energy required to move mass *m* from its initial position? (Neglect resistive forces)



(1) It takes less energy to move it to *A* because the distance is longer but the force is attractive.

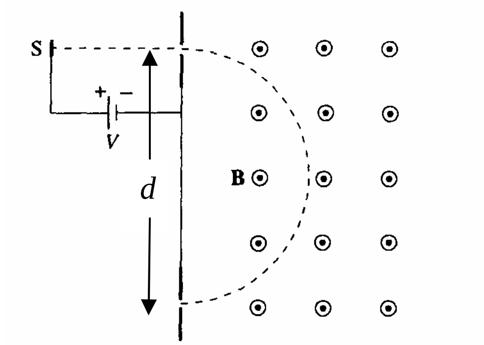
(2) It takes less energy to move it to *B* because the distance is less.

(3) It takes the same amount of energy to move the mass to *A* or to *B*.

(4) There is not enough information to answer this question because the answer depends on the path taken by mass *m*.

(5) There is not enough information to answer this question because the answer depends on the velocity of the mass as it moves.

(16) A mass spectrometer is a device that selects molecular species of a fixed mass. An ion with electric charge $q > 0$ and mass m starts from rest at a source S and accelerates through a potential difference V. It passes through a hole into a region with a constant magnetic field of flux density B perpendicular to the plane as shown in the figure. The ion is deflected by the magnetic field and emerges through the hole at the bottom as shown in the figure, a distance d from the hole at the top. The mass m of the ion is given by



(1) $m = \frac{qBd}{8V}$

(2) $m = \frac{qB^2d^2}{8V}$

(3) $m = \frac{8qV}{B^2}$

(4) $m = \frac{2qVB^3}{d}$

(5) $m = \frac{q^2B}{3Vd^3}$

(17) Two persons are standing on opposite sides of a wide tree. They cannot see each other, but they can hear each other's voice. This happens because

(1) The frequency of light waves is much greater than the frequency of sound waves.

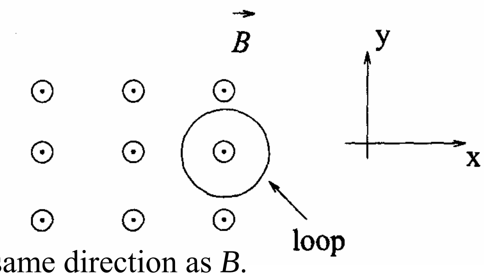
(2) The wavelength of light waves is much smaller than the wavelength of sound waves.

(3) The intensity of light waves is much greater than the intensity of sound waves.

(4) The wavelength of light waves is much greater than the wavelength of sound waves.

(5) The speed of light waves is much greater than the speed of sound waves.

(18) A circular loop of wire is positioned half in and half out of a square region of uniform magnetic field B directed in the $+z$ direction, out of the paper, as shown. To induce a counterclockwise current in this loop,



(1) it has to be moved in the $+y$ direction

(2) it has to be moved in the $-x$ direction

(3) it has to be moved along the $+z$ axis, in the same direction as B.

(4) it has to be moved along the $-z$ axis, in the direction opposite to B.

(5) it has to be moved in the $+x$ direction

(19) Saturn is 10 times farther from the Sun than the Earth. Which of the following best approximates Saturn's orbital period?

(1) $\sqrt{10}$ years

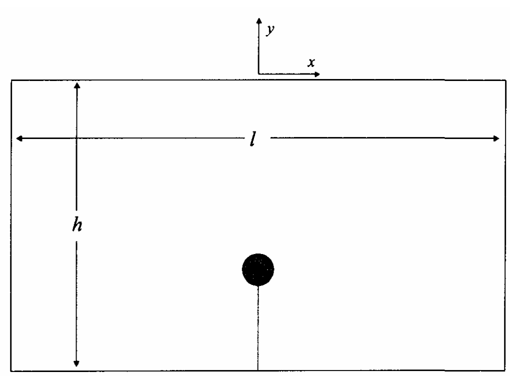
(2) 10 years

(3) 30 years

(4) 100 years

(5) 1000 years

(20) A helium filled balloon is anchored to the bottom center of an enclosed stationary cart and floats in the middle of the cart. The cart has length l and height h. The cart is now given a constant acceleration $a > 0$ to the right. Afterwards the string anchoring the balloon is cut. The string has negligible mass, and you may assume that the first thing the balloon hits is the ceiling. Where does the balloon hit the ceiling? The origin of the coordinate system is directly above the point where the balloon is fastened to the floor.



(1) $x = -\dfrac{ha}{g}$

(2) $x = 0$

(3) $x = \dfrac{ha}{g}$

(4) $x = \dfrac{la}{g}$

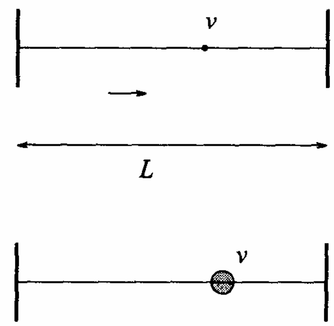
(5) $x = \dfrac{hla}{g\sqrt{l^2 + h^2}}$

PART B

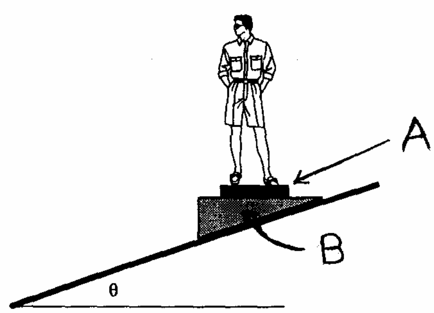
(1) A very small bead of mass m is sliding back and forth on a smooth horizontal wire held between two rigid walls as shown in the figure. There is no friction. The length of the wire is L and the speed of the mass is v. Assuming that the collisions with the wall are perfectly elastic,

(i) Derive an expression for the average force (F_1) that the bouncing bead exerts on one of the walls.

(ii) Deduce an expression for the average force (F_2) that the bouncing bead exerts on one of the walls if the diameter of the bead is not negligibly small, but has the value d.



(2) A weighing scale (A) is fixed firmly to a wedge (B). A person of mass M is standing on the scale. The wedge is on a frictionless inclined ramp that makes an angle θ to the horizontal as shown in the figure. The system is sliding down the ramp with an acceleration a. The reading of the scale registers the apparent weight of the person. Derive an expression for the apparent weight W of the person as he slides down. (Hint: write down equations of motion considering the person alone and scale-wedge-person as one unit. Note that there is friction between the feet of the person and the scale)



(3) For a steady flow of a viscous incompressible fluid, the amount (volume) of fluid flowing per unit time through the tube is given by the usual Poiseuille's formula

$$\Delta V = \frac{\pi r^4}{8\eta l}\,\Delta P$$

Where Δp is the pressure difference between ends of the tube of length l and radius r. η is the viscosity of the fluid.

Poiseuille's formula can be rewritten as,

$$\Delta V = \frac{\Delta P}{R}$$

where $R = \frac{8\eta l}{\pi r^4}$ is interpreted as the resistance offered by the pipe to fluid flow.

The equation $\Delta P = R\Delta V$ is analogous to Ohm's law of electrical circuits.

Consider the blood circulation of a man at rest. The total blood flow rate from the left ventricle to the right auricle of the heart is 100 $cm^3 s^{-1}$. Answer the following questions under the assumption that all capillary vessels are connected in parallel and that each of them has radius r = 4 μm and length l = 1 mm and operates under a pressure difference of 1 kPa. (viscosity of the blood is 4.5×10^{-3} kg $m^{-1}s^{-1}$)

(i) Calculate the resistance (R) offered by a single capillary.

$$\left(\text{Take } \frac{8\times4.5}{\pi\times256} = 0.045\right)$$

(ii) How many (N) capillary vessels are in the human body?

(iii) Determine the velocity (υ) with which blood is flowing through a capillary vessel?

$$\left(\text{Take } \frac{1}{4.5\times\pi\times16} = 0.0044\right)$$

ANSWER SHEET FOR PART B

QUESTION NUMBER	ANSWERS	MARKS (examiner's use)
1 (i)	$F_1 =$	
(ii)	$F_2 =$	

2.	$W =$	

3. (i)	$R =$	
(ii)	$N =$	
(iii)	$v =$	