SRI LANKAN PHYSICS OLYMPIAD
COMPETITION – 2016

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

Date of Examination : 18 – 06 – 2016 **Index No. : .....**

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

INSTRUCTIONS

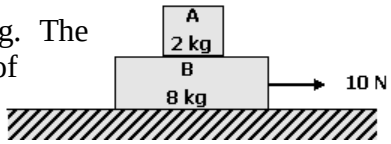
Answer all questions

- **There are two parts (A and B) in this paper.**
- **Part A contains 15 multiple choice questions. Underline the response corresponding to your choice in each question. If you change the choice of an answer, the previous underline mark must be completely erased/removed.**
- **Part B contains two questions.**
- **Use the papers provided to do all the derivations.**
- **At the end of each question an answer sheet is provided for you to write down the corresponding final expressions or numerical answers.**
- **At the end of the exam, handover the full question paper together with the final answer sheets.**
- **Handover the papers used to work out the problems separately with your index number written on each paper.**
- **Do not detach any sheet from the question paper.**

PART A

($g = 10\ \mathrm{m\,s^{-2}}$)

1. Block *A* of mass 2 kg is placed over block *B* of mass 8 kg. The combination is placed over a rough horizontal surface. Coefficient of friction between *B* and the floor is 0.5. Coefficient of friction between *A* and *B* is 0.4. A horizontal force of 10 N is applied on block *B*. The frictional force acting between *A* and *B*, and *B* and the floor respectively are



(1) zero, zero (2) zero, 10 N (3) 8 N and zero (4) 8 N and 10 N (5) 8 N and 50 N

2. An object is projected vertically upwards from the ground with a speed of $15\ \mathrm{m\,s^{-1}}$. While ascending and descending the corresponding times that the object passes a point at a height 10 m from the ground are respectively,

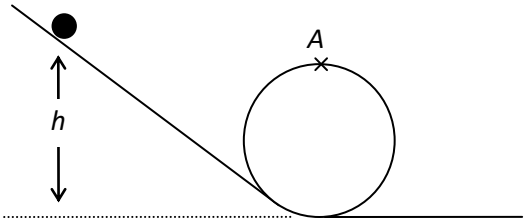
(1) 1.0 s, 2.0 s (2) 0.5 s, 2.0 s (3) 1.5 s, 2.0 s (4) 1.0 s, 3.0 s (5) 1.5 s, 3.0 s

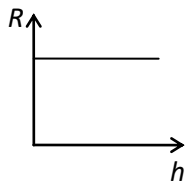
3. With the propagation of a longitudinal wave through a material medium, the quantities transmitted along the propagation direction are

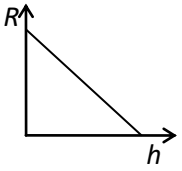
(1) Energy, momentum and mass (2) Energy only (3) Energy and mass

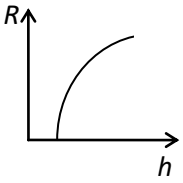
(4) Energy and momentum (5) Mass and momentum

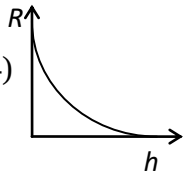
4. A ball bearing is released from rest at a height h on a smooth track and completes the circular loop of the track. If R is the reaction acting on the ball bearing at the highest point A of the loop, which of the following graphs correctly shows the variation of R with h?

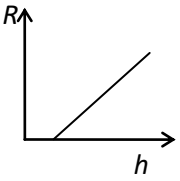


(1) 

(2) 

(3) 

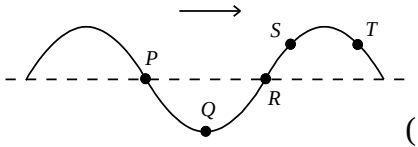
(4) 

(5) 

5. An open tube of air supports standing waves at frequencies of 300 Hz and 400 Hz, and at no frequencies between these two. The second harmonic of this tube has frequency of

(1) 800 Hz. (2) 600 Hz. (3) 400 Hz. (4) 200 Hz. (5) 100 Hz.

6. A transverse wave propagating to the right along a string is shown in the figure. At the moment shown, out of the particles labeled as P, Q, R, S, and T which point has its velocity and acceleration in opposite directions?



(1) P (2) Q (3) R (4) S (5) T

7. The image of the moon is focused on a screen by a converging lens of focal length 20 cm. If the moon subtends an angle of 9.5×10^{-3} radians at the centre of the lens, the diameter of the image is

(1) 4.8×10^{-2} cm (2) 9.5×10^{-2} cm (3) 1.9×10^{-1} cm (4) 3.8×10^{-1} cm (5) 7.6×10^{-1} cm

8. A boat has green light of wavelength 500 nm on its mast. What wavelength would be measured and what colour would be observed for this light as seen by a diver submerged in water by the side of the boat? The refractive index of water for green colour $n_w = 4/3$.

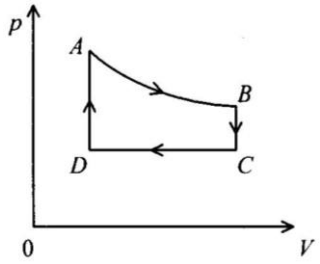
(1) Green of wavelength 375 nm (2) Blue of wavelength 375 nm
(3) Green of wavelength 500 nm (4) Red of wavelength 665 nm
(5) Yellow of wavelength 500 nm

9. Which of the following statements is/are correct?

(A) The boiling point of pure water increases with atmospheric pressure.
(B) When pure water is boiling, the supplied energy is transformed into the kinetic energy of the water molecules.
(C) When pure water is boiling, the supplied energy is transformed into the intermolecular potential energy.

(1) (A) only (2) (A) and (B) only (3) (B) and (C) only (4) (A) and (C) only
(5) All (A), (B) and (C)

10. The variation of pressure *P* against volume *V* of a fixed mass of an ideal gas when it undergoes a cyclic process, *ABCD* is shown in the *P*-*V* diagram below.



Consider the following statements
(A) During the process *A* to *B*, work is done by the gas.
(B) During the process *B* to *C*, heat is extracted from the gas.
(C) During the process *C* to *D*, the internal energy of the gas increases.

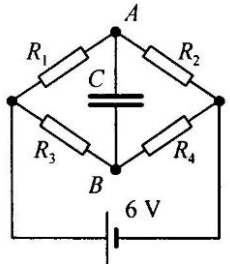
Which of the following statements is/are correct?

1. (A) only 2. (B) only 3. (A) and (B) only 4. (A) and (C) only
5. (A), (B) and (C) all

11. A thin circular ring of radius *r* is uniformly charged to a charge *q* per unit length. How much work has to be done to bring another point charge *Q* from infinity to the centre of the circle? (ε_0 = permittivity of free space)

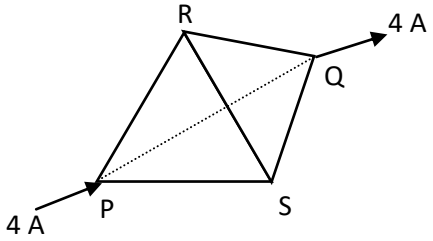
(1) 0 (2) $qQ/(4\pi\varepsilon_o r)$ (3) $qQ/2\varepsilon_0$ (4) $qQ/2\pi\varepsilon_0 r$ (5) $qQ/4\varepsilon_0$

12. In the above circuit, the cell has an e.m.f. 6 V and negligible internal resistance. The resistances of the four resistors R_1, R_2, R_3 and R_4 are 12 Ω, 6 Ω, 2 Ω and 4 Ω respectively. The capacitor has capacitance 10 μF. At steady state, the charge on the capacitor plate connecting to *A* is



(1) -20 μC (2) -40 μC (3) 0 (4) $+20$ μC (5) $+40$ μC

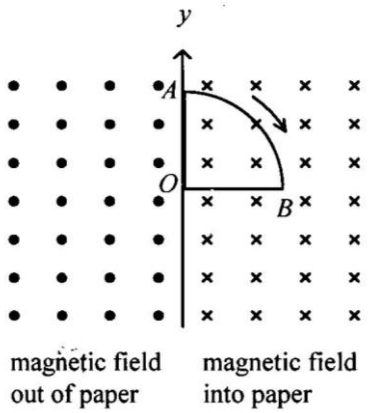
13. Six wires, each of resistance 2 Ω, are joined to form a regular tetrahedron *PQRS*. A current of 4 A flows (enters from *P* and leaves from *Q*) across the tetrahedron at *P* and *Q*.
Which of the following statements is/are correct?

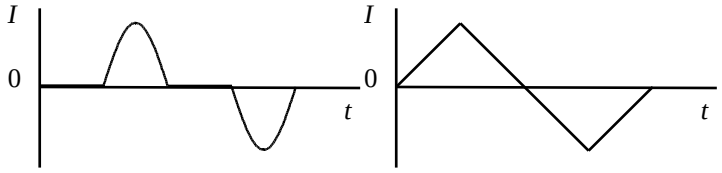


(A) Points *R* and *S* are at the same potential.
(B) The current in wire *PR* is 1 A.
(C) The potential drop across *PQ* is 4 V.

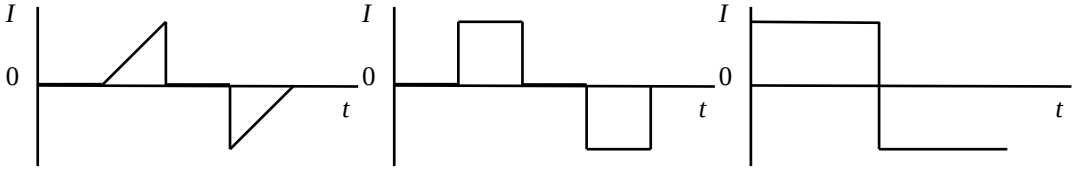
(1) (A) only (2) (B) only (3.) (A) and (B) only (4) (A) and (C) only
(5) All (A), (B) and (C)

14. Two uniform magnetic fields of equal magnitude but with one into paper and the other out of paper, are separated on the two sides of the *y*-axis as shown. A wire is bent into a closed loop *OABO*, which is shaped as a quarter of a circle. It is rotated uniformly in a clockwise direction about *O* on the plane of the paper. Which of the following graphs best shows the variation of current, *I*, in the loop with time, *t*, in one revolution?



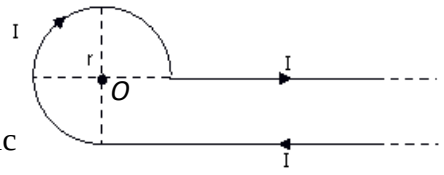


(1) (2)



(3) (4) (5)

15. Current , *I* is flowing in a conductor shaped as shown in the figure. The radius of the curved part is *r* and the lengths of straight portion are very large. The magnitude and direction of the magnetic flux density at the centre *O* will be



(1) $(\mu_o I/4\pi r)[3\pi/2 + 1]$ out of the paper

(2) $(\mu_o I/4\pi r)[3\pi/2 + 1]$ into the paper

(3) $(\mu_o I/4\pi r)[3\pi/2 - 1]$ into the paper

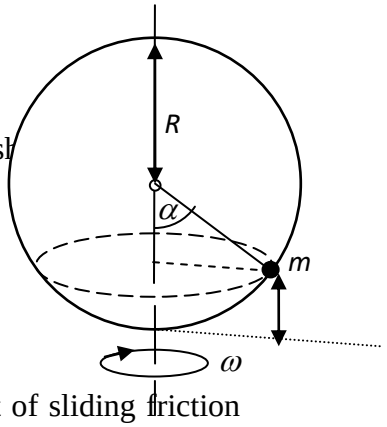
(4) $(\mu_o I/4\pi r)[3\pi/2 - 1]$ out of the paper

(5) $(\mu_o I/2\pi r)[\pi/2 + 1)]$ into the paper

PART B

Acceleration due to gravity = g

(1) A hollow sphere of radius R rotates about a vertical axis through its centre with an angular velocity ω. Inside the sphere a small bead of mass m is moving together with the sphere **without slipping** at a certain height as shown in the figure. The radial distance from the center of the sphere to the bead makes an angle α with the vertical.



(a) Draw the forces acting on the bead relative to an inertial observer on the ground. Assume that the bead tends to slide down along the inner surface of the sphere.

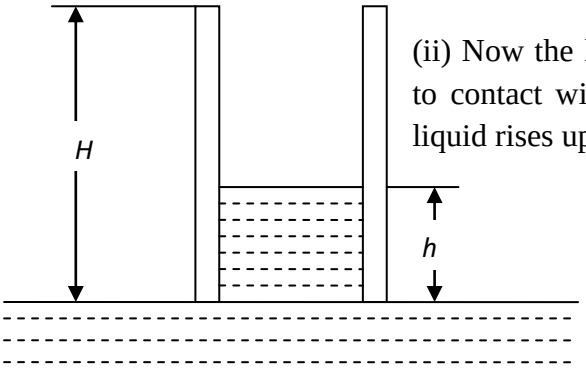
(b) Derive an expression for the minimum value (μ_s) that the coefficient of sliding friction between the bead and the inner surface of the sphere must have to fulfill the above condition? Your expression should be in terms of ω, R, α, and g.

(c) A student claims that, If $\frac{\omega^2 R\cos(\alpha)}{g} > 1$, then some friction is necessary to prevent the bead slipping upwards. Is this statement TRUE or FALSE?

(2) A charged parallel plate capacitor with rectangular plates of height H and width l is fixed in a vertical position in air. The plate separation between the plates is d.

(i) (a) Write down an expression for the capacitance (C_0) of this air filled capacitor in terms of the permittivity of air ϵ_0, H, l and d.

(b) Write down an expression for the energy stored (W_0) in the capacitor in terms of the electric field intensity (E_0) of the charged capacitor, C_0, and d.



(ii) Now the lower edges of the plates of this capacitor is made to contact with a dielectric liquid as shown in the figure. The liquid rises up in between the plates to a height h.

(a) Write down an expression for the equivalent capacitance (C_1) of this partly liquid filled capacitor in terms of ϵ_0, H, l, d, h and the relative permittivity ϵ_r of the liquid.

(b) Write down an expression for the increase in the gravitational potential energy (W_1) of the liquid in terms of the density (ρ) of the liquid, h, l, and g.

(c) Using the facts that total electric charge in the capacitor remains constant and there is no energy transferred to the system from outside, derive **an expression in order to find** the height (h), in terms of the initial electric field intensity E_0 of the charged capacitor, H, ρ, ϵ_r, ϵ_0, and g. All the other symbols should cancel off. No need to keep h as the subject.

ANSWER SHEET

Question 1	Results	Marks
(a)		
(b)	μ_S =	
(c)	**Underline the correct answer: TRUE or FALSE**	

Question 2	Results	Marks
(i) (a)	$C_0 =$	
(b)	$W_0 =$	
(ii) (a)	$C_1 =$	
(b)	$W_1 =$	
(c)		