SRI LANKAN PHYSICS OLYMPIAD COMPETITION – 2017

Time Allocated : 02 Hours
Date of Examination : 16 – 09 – 2017
Time : 9.00 a.m. - 11.00 a.m.

Calculators are not allowed to use.
Index No. : ....

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 one (1) question.**
- **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

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

1. Which of the following is/are vector quantities?

(1) impulse (2) pressure (3) moment of inertia

A. (1) only B. (3) only C.(1) and (2) only D.(2) and (3) only
E. All (1), (2) and (3)

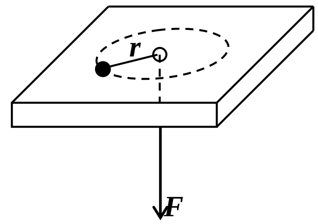
2. A stone is projected at an angle of 45° to the horizontal with an initial kinetic energy E. When the stone is at its maximum height, its kinetic energy is (Neglect air resistance.)

A. $\frac{E}{4}$ B. $\frac{E}{2}$ C. $\frac{3E}{4}$ D. $\frac{E}{\sqrt{2}}$ E. $\sqrt{E}$

3. A diver at a depth of d below a water surface looks up and finds that the sky appears to be within a circle of radius r. The critical angle of water is given by

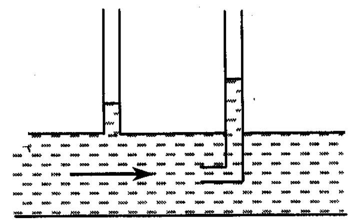
A. $\tan^{-1}(r/d)$ B. $\sin^{-1}(r/d)$ C. $\tan^{-1}(d/r)$ D. $\sin^{-1}(d/r)$ E. $\cos^{-1}(d/r)$

4. As shown, a small sphere is connected to one end of a string which passes through a hole on a horizontal frictionless board. The other end of the string is pulled by a downward force F so that the sphere performs a uniform circular motion with a radius r. The force F is gradually increased until the radius reduces steadily to $r/2$. The ratio of the new kinetic energy of the sphere to its original kinetic energy is (Neglect any friction between the string and the hole.)



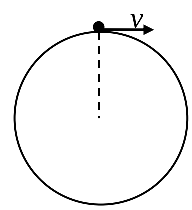
A. 4:1 B. 2:1 C. 1:1 D. 1:2 E. 1:4

5. The velocity of an incompressible, non-viscous liquid in steady flow is measured by Pitot-tubes. The difference in heights of the liquid columns in the tubes shown is h. If the velocity of flow is halved, the difference in heights of liquid columns would become



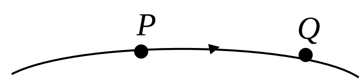
A. 1.4h B. 2h C. 2.8h D. 4h E. (1/4)h

6. Suppose a spacecraft is launched with an initial speed v and it eventually enters a circular orbit near the earth's surface as shown. If the launching speed was increased to 2v, the spacecraft would (Neglect air resistance.)



A. revolve uniformly in a circular orbit around the earth with a longer period.
B. revolve uniformly in a circular orbit around the earth with a shorter period.
C. revolve in an elliptical orbit around the earth with a longer period.
D. leave the earth and travel to outer space.
E. revolve uniformly in a circular orbit around the earth with the same period.

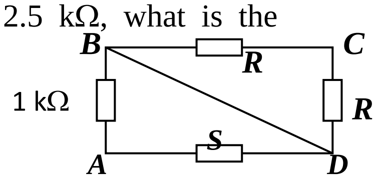
7 The figure below shows the trajectory of a positively charged particle travelling along a curve from P to Q in an electric field. The particle is subject to electrostatic forces only. Which of the following deductions must be correct?



(1) The curve is one of the field lines in the field.
(2) P is at a higher electric potential than Q.
(3) The sum of kinetic energy and electrical potential energy of the particle at P is equal to that at Q.

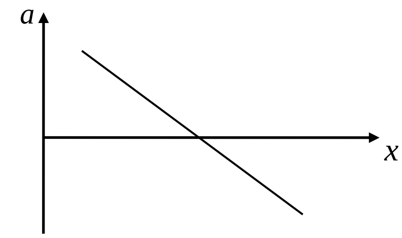
A. (2) only B. (3) only C. (1) and (2) only D. (1) and (3) only
E. All (1), (2) and (3)

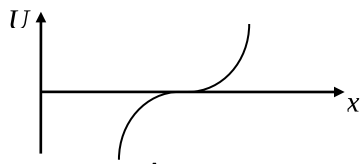
8. In the network of resistors shown below, the resistance of S is infinitely large and the two resistors R are identical. If the equivalent resistance across CD is 2.5 kΩ, what is the equivalent resistance across AC?



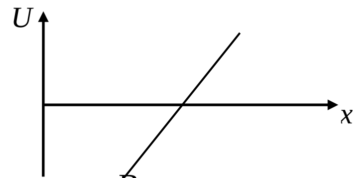
A. 2.5 kΩ B. 3.5 kΩ C. 5.0 kΩ D. infinity
E. Zero

9. The graph shows the variation of the acceleration a of a particle with its displacement x from a fixed point. Which of the following graphs shows the variation of its potential energy U with x?

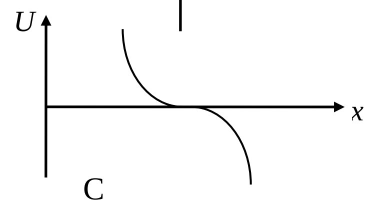




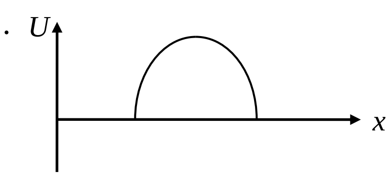
A



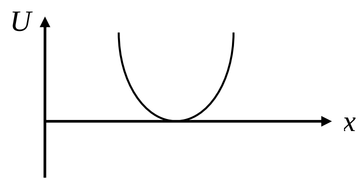
B



C



D

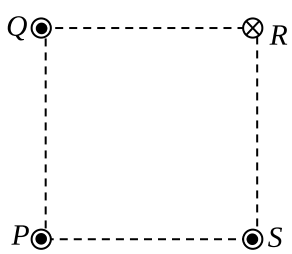


E

10. Which of the following thermodynamic processes on a fixed mass of an ideal gas is <u>impossible</u>?

A. It absorbs heat and expands while its internal energy increases.
B. It absorbs heat and expands while its internal energy decreases.
C. It absorbs heat and is compressed while its internal energy decreases.
D. It liberates heat and is compressed while its internal energy increases.
E. Its internal energy increases when it is heated while the volume is kept constant.

11.



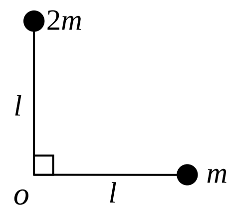
Four long straight current-carrying wires perpendicular to the plane of the paper are arranged at the comers of a square $PQRS$ as shown. Identical currents of I flow along the wires at P, Q and S while the current flowing along the wire at R is in the opposite direction. If the wire at P experiences no net force, the current flowing in the wire at R is,

A. $I/\sqrt{2}$ B. $I/2$ C. $\sqrt{2}I$ D. $2I$ E. $4I$

12. A metal rod of length 1.0 m is hit with a hammer at one end. It takes 5.0×10^{-4} s for the compression pulse generated to travel to the other end and reflected back to the end hit by the hammer. The Young modulus of the metal is
(density of the metal = 9.0×10^{3} kg m^{-3})

A. 1.4×10^{11} Pa   B. 0.6×10^{11} Pa   C. 3.3×10^{7} Pa   D. 1.6×10^{7} Pa
E. 1.2×10^{7} Pa

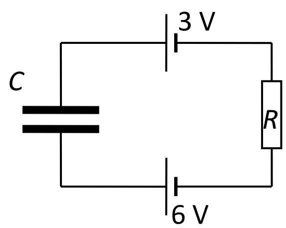
13. An L-shaped frame hinged freely at a fixed point *O* is formed by two identical light rigid rods of length *l*. The rods are perpendicular to each other and two small beads of masses *m* and 2*m* are attached to the ends of the rods as shown. The system is released from rest with 2*m* vertically above *O*. The angular velocity of the system when *m* is vertically below *O* is



A. $2\sqrt{\frac{g}{l}}$ B. $\sqrt{\frac{3g}{l}}$ C. $\sqrt{\frac{2g}{l}}$

D. $\sqrt{\frac{g}{l}}$ E. $\sqrt{\frac{4g}{l}}$

14.

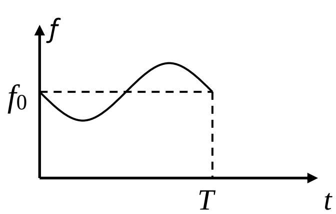


Which of the following is/are correct for the above circuit at the steady state?

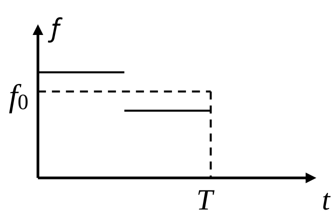
(1) The current in the circuit is zero.
(2) The voltage across *C* is independent of its capacitance.
(3) The voltage across *C* is independent of the resistance of *R*.

A. (1) and (2) only B. (1) and (3) only C. (2) and (3) only D. (1) only
E. All (1), (2) and (3)

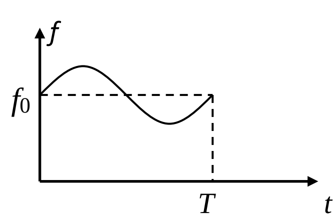
15. A boy sitting at the rim of a rotating merry-go-round blows a whistle continuously with a frequency of f_0. An observer on the ground hears the sound of the whistle. Which of the following graphs gives the most possible variation of the observed frequency *f* of the sound in a period of revolution *T*?



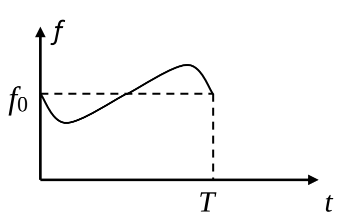
A



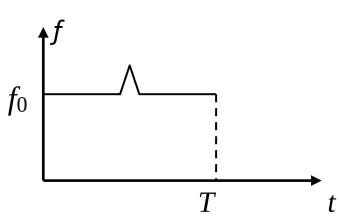
B



C



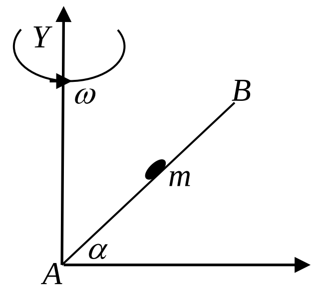
D



E

PART B

Acceleration due to gravity = g



(1) (a) A rectangular rod AB fixed at one of its end A makes an angle α to the horizontal as shown in the figure. ($\omega = 0$) A body of mass m is placed on the rod and it could slide along the rod. The coefficient of static friction (μ) between the body and the rod is given by $\mu = \tan\beta$. The angle β is called as the angle of friction.

(i) Determine the relationship between α and β for the body to remains at rest on the rod.

(ii) Determine the relationship between α and β for the body to slide along the rod.

(b) Now the rod is hinged freely at end A and it revolves about a vertical axis Y with an angular velocity ω. The angle α does not change during rotation.

The body could be at rest relative to the rod at two different places on the rod. Derive expressions for the two distances (l_1 and l_2) from the end A along the rod where the body could remain at rest relative to the rod. Your expressions should be written in terms of g, ω, α, β and should simplify to the last step.

You can use the following relations:

$\sin(\alpha \pm \beta) = \sin\alpha\cos\beta \pm \cos\alpha\sin\beta$; $\cos(\alpha \pm \beta) = \cos\alpha\cos\beta \mp \sin\alpha\sin\beta$

ANSWER SHEET

Question 1	Results	Marks
(a) (i)		
(ii)		
(b)	l_1 =	
	l_2 =	