



INSTITUTE OF PHYSICS, SRI LANKA
18th SRI LANKAN PHYSICS OLYMPIAD COMPETITION - 2024

Time Allocated: 02 Hours

Calculators are not allowed.

Date of Examination: 14.09.2024

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

Index No.:

Name:....., TP/Mobile Phone No:....., Email:.....

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 underlined mark must be completely erased/removed.**
- **Part B contains two (2) 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, hand over the full question paper together with the final answer sheets.**
- **Hand over 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
($g = 10 \text{ m s}^{-2}$)

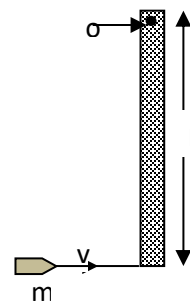
1. Which of the following pairs represent two vector quantities?
(a) Mass, Acceleration
(b) Temperature, Torque
(c) Velocity, Impulse
(d) Gravitational Intensity, Work
(e) Distance, Speed
2. The intensity of sound from a point sound source is 20 mW m^{-2} at a distance of 5.0 m from the sound source. What is the intensity of sound at a distance of 25 m from the source?
(a) 0.002 mW m^{-2} (b) 0.04 mW m^{-2} (c) 0.6 mW m^{-2}
(d) 0.80 mW m^{-2} (e) 8.0 mW m^{-2}
3. Pitch of a tuning fork **does not** depend on
(a) Length of the prong
(b) Density of the material of the prongs
(c) Young modulus of the material of the prongs
(d) Thickness of the prong in the direction of the vibration of the fork
(e) The gap between the two prongs
4. A 220 V , 100 W filament bulb is connected across a 110 V DC voltage supply. The power consumed by the bulb is
(a) 2.0 W (b) 10 W (c) 15 W (d) 25 W (e) 125 W
5. A particle of mass m and charge e moves with a velocity v in a magnetic field B applied perpendicular to the motion of the particle. The radius of curvature of the path of the particle in the magnetic field is
(a) mv/Be (b) mB/ev (c) Bv/em (d) Be/mv (e) me/Bv

6. A ray of monochromatic light passes from air into a block of glass. The wavelength and the speed of this light in vacuum are $6.0 \times 10^{-7} \text{ m}$ and $3.0 \times 10^8 \text{ m s}^{-1}$ respectively. The refractive index of the glass for this light is 1.50. The frequency of this light in the glass is

- (a) $2.0 \times 10^{-15} \text{ Hz}$ (b) $1.26 \times 10^2 \text{ Hz}$ (c) $1.89 \times 10^2 \text{ Hz}$
 (d) $5.0 \times 10^{14} \text{ Hz}$ (e) $7.14 \times 10^{14} \text{ Hz}$.

7. A uniform thin rod of mass M and length L is hinged by a frictionless pivot at its end O , as shown in the figure below. A bullet of mass m moving horizontally with a velocity v strikes the free end of the rod and gets embedded in it. The angular velocity of the system about O just after the collision is (moment of inertia of the rod around $O = (ML^2)/3$).

- (a) $\frac{mv}{L(M+m)}$ (b) $\frac{3mv}{L(M+3m)}$ (c) $\frac{3mv}{L(M+2m)}$
 (d) $\frac{mv}{LM}$ (e) $\frac{mv}{L(M-m)}$



8. An object O is kept at a distance D from a screen. A convex lens of focal length f is then moved between the screen and the object. A clear real image of the object could be obtained at two positions of the lens named A and B . If $OA = u_1$ and $OB = u_2$, the correct expression/s is/are

- (A) $f = u_1 u_2 / D$
 (B) $D = u_1 + u_2$
 (C) $u_1 + u_2 > 4f$

- (a) Only (A) (b) Only (A) and (B) (c) Only (A) and (C)
 (d) Only (B) and (C) (e) All (A), (B) and (C)

9. A uniform rod AB of mass m and length L is suspended by two strings C and D of negligible mass as shown in figure below. When the string D is cut, the tension in the string C (just after the string D is cut) will be (Moment of inertia of the rod around $A = (mL^2)/3$)

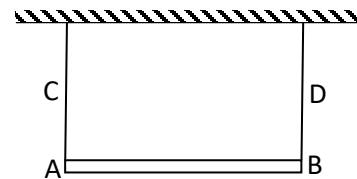
(a) $\frac{mg}{4}$

(b) mg

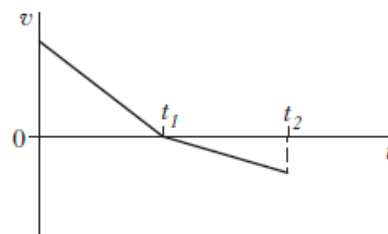
(c) $2mg$

(d) $4mg$

(e) $\frac{mg}{2}$

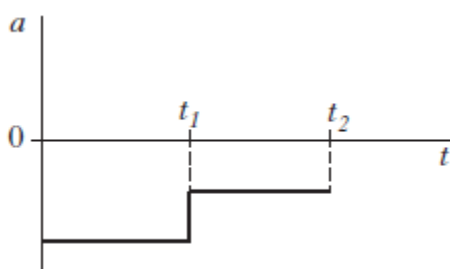


10. A trolley travels along a straight path. The graph below shows how the velocity of the trolley varies with time.

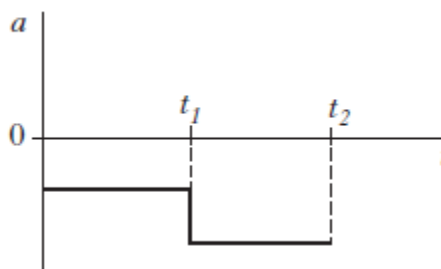


Select the correct graph which shows how acceleration (a) of the trolley varies with time t .

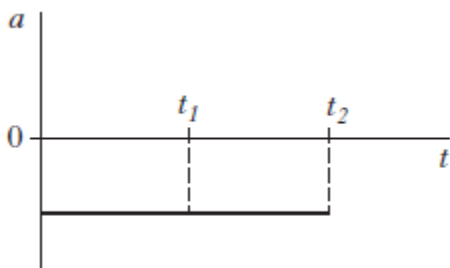
(a)



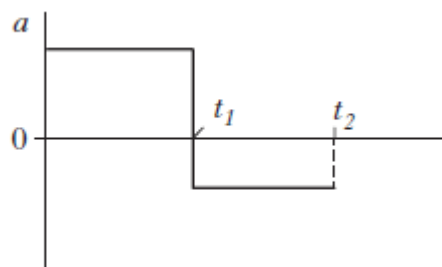
(b)



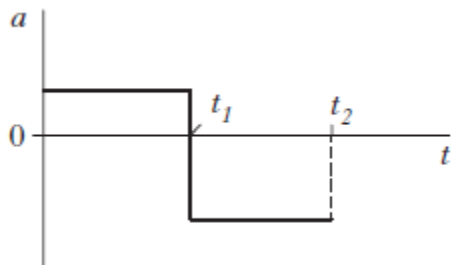
(c)



(d)

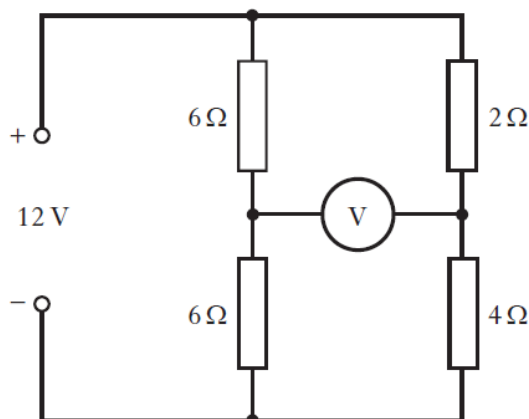


(e)



11. In the circuit given below, the reading on the voltmeter (V) is
(Assume that there is no internal resistance in the battery)

- (a) 0 V
- (b) 2 V
- (c) 6 V
- (d) 8 V
- (e) 12 V.

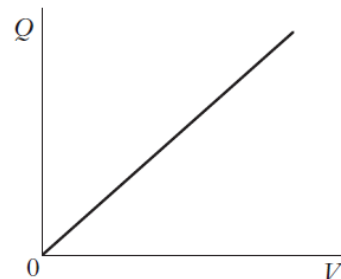


12. The graph shows how the charge, Q , stored in a capacitor varies with the potential difference, V across the capacitor. Which of the following statement/s is/are correct ?

I. Reciprocal of the gradient of the graph represents the capacitance of the capacitor.

II. The area under the graph represents twice the work done in charging the capacitor.

III. The energy, E , stored in the capacitor is given by the equation $E = (1/2)QV^2$.

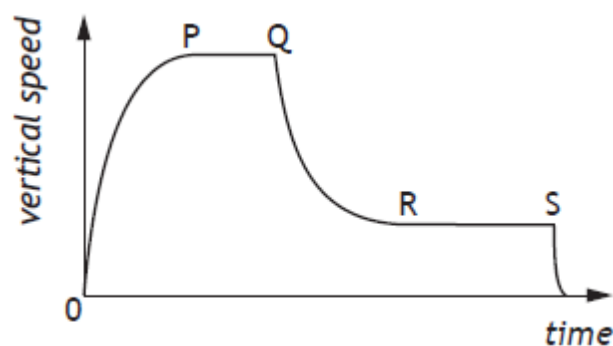


- (a) I only
- (b) II only
- (c) III only
- (d) I and II only
- (e) None (All I, II and III are wrong)

13. The graph given below shows how the vertical speed of a skydiver varies with time.

With reference to the graph given here, a student makes the following conclusions.

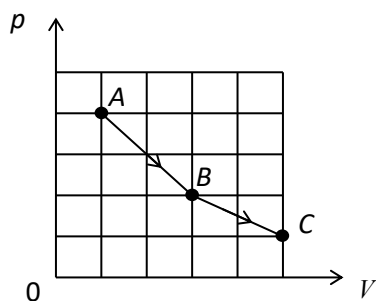
- I The acceleration of the skydiver is greatest between P and Q.
- II The air resistance acting on the skydiver between Q and R is less than the weight of the skydiver.
- III The forces acting on the skydiver are balanced between R and S.



Out of the above, the correct conclusion/s is/are

- (a) I only
- (b) II only
- (c) III only
- (d) I and II only
- (e) All I , II and III

14. As shown in the p - V graph below, an ideal gas of volume V and pressure p undergoes a change from state A to state C via state B along the path as shown in the p - V graph below.



If the absolute temperatures of the gas corresponding to the states A , B and C are T_A , T_B , and T_C respectively, the correct statement about those temperatures of the ideal gas is

- (a) $T_A < T_B < T_C$.
- (b) $T_A < T_C < T_B$
- (c) $T_B < T_C < T_A$
- (d) $T_B < T_A < T_C$
- (e) $T_C < T_A < T_B$

15. Weight of an empty balloon is W_1 . When it is filled with a certain amount of air of weight W , the total weight of the balloon is W_2 . Assuming that the density of air outside and inside of the balloon is same, the correct statement is,

- (a) $W_2 = W_1 + W$
- (b) $W_2 = W_1 - 2W$
- (c) $W_2 = W_1$
- (d) $W_2 = W_1 - W$
- (e) $W_2 = W_1 + W/2$

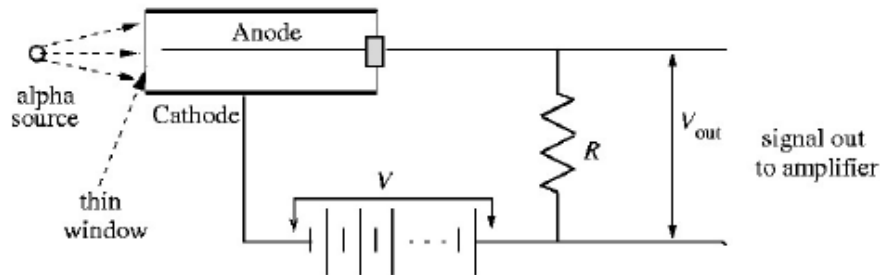
PART B

- (1) Earth and Jupiter are revolving around the Sun. The average distance from the Sun to the earth is 1.5×10^8 km. The period of revolution of the Earth and Jupiter about the Sun are 1 year (365 days) and 12 years respectively. Assume that the orbits of Earth and Jupiter are circles.

- (a) Determine the distance R_J from the Sun to Jupiter. Take $12^{2/3} = 5.25$
- (b) Determine the relative angular velocity ω (in rad day^{-1}) of the earth with respect to the frame of reference of Sun and Jupiter. Take $\pi = 3$; $\frac{1}{12} = 0.08$; $\frac{6}{365} = 0.0164$

Q(1)	Answer	Marks
(a)	$R_J =$	
(b)	$\omega =$	

- (2) For monitoring α particles, one can use an ionization chamber shown in the figure, which is a gas-filled detector that operates on the principle of separation of positive and negative charges created during the ionization of gas atoms by the particle. The collection of charges yields a pulse that can be detected, amplified and then recorded. The voltage difference between anode and cathode is kept sufficiently high so that there is a negligible amount of recombination of charges during their passage to the anodes.



- (a) An ionization chamber electrometer system with a capacitance of 40.0 pF is used to detect α particles having an energy of 6.0 MeV. Assume the energy required to produce an ion-pair consisting of a light negative electron and a heavier positive ion, each carrying one electronic charge of magnitude $e = 1.6 \times 10^{-19}$ C in air is 30.0 eV.
- (i) What is the charge Q produced by ionization due a α particle?
- (ii) What will be the magnitude of the voltage V produced by each α particle?

(b) The smallest detectable saturation current with this instrument is 10^{-12} A. Calculate the lowest activity A of the source that could be detected by this instrument assuming a 10 % efficiency for the detector.

(c) Determine the necessary voltage pulse amplification G required to produce a 0.25 V signal.

Q(2)	Answer	Marks
(a) (i)	$Q =$	
(ii)	$V =$	
(b)	$A =$	
(c)	$G =$	