JELET Physics Sample Paper-1

Duration: 35 Minutes **Maximum Marks: 35**

Instructions

- This paper contains **30** Multiple Choice Questions divided into **2 Sections**.
- **Section A (Q1–Q25):** Each correct answer carries **+1 mark**. Incorrect answer: **−0.25** marks. Only **one** correct option.
- **Section B (Q26–Q30):** Each correct answer carries **+2 marks**. **No negative marking**. One or **more** correct options may be correct; full marks only if all correct options are marked.
- Unattempted questions carry **0** marks.
- Use of mobile phones, smartwatches, calculators, or any electronic gadgets is strictly prohibited.

Section–A — 25 Questions × 1 Mark Each
(Negative Marking: −0.25) [Single Correct]

Q1. A block of mass $m = 2$ kg is placed on a rough horizontal surface. A time-varying horizontal force $F = 4t$ (where t is in seconds and F is in Newtons) is applied to the block. If the coefficient of static friction is $\mu_s = 0.4$ and kinetic friction is $\mu_k = 0.3$, what is the acceleration of the block at $t = 3$ s? (Take $g = 10$ m/s^2)

(A) 3.0 m/s^2

(B) 2.0 m/s^2

(C) 3.2 m/s^2

(D) 0 m/s^2

Q2. A light ray travelling inside an optical fiber core of refractive index $n_1 = 1.52$ encounters the cladding interface at an angle of incidence of 72°. For total internal reflection to strictly occur, what is the maximum permissible refractive index n_2 of the cladding material?

(A) 1.41

(B) 1.48

(C) 1.45

(D) 1.39

Q3. A spherical solid marble of mass M and radius R rolls smoothly from rest down an inclined plane without slipping. What fraction of its total kinetic energy is associated with its rotational motion about its center of mass?

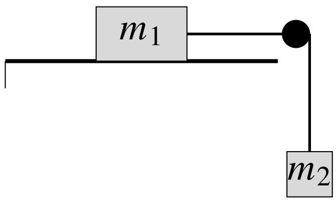
(A) $\frac{2}{5}$

(B) $\frac{2}{7}$

(C) $\frac{5}{7}$

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

Q4. Consider the system shown in the diagram below. A block of mass $m_1 = 3$ kg rests on a frictionless horizontal table and is attached via a light, inextensible string passing over an ideal pulley to a hanging mass $m_2 = 2$ kg. When the system is released from rest, what is the magnitude of the tension T in the string? (Take $g = 10$ m/s^2)



(A) 12 N

(B) 20 N

(C) 8 N

(D) 15 N

Q5. A precise measurement of a cylinder's radius yields $R = 2.00 \pm 0.02$ cm and its length yields $L = 10.0 \pm 0.1$ cm. What is the maximum percentage error in the calculated volume of this cylinder?

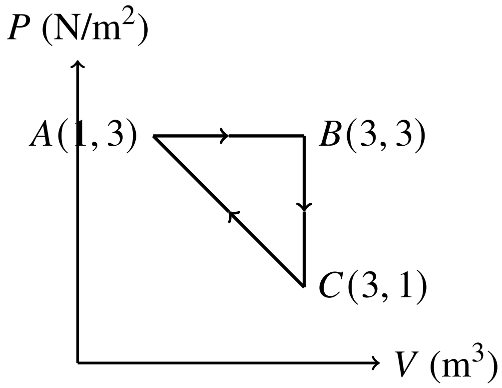
(A) 2%

(B) 3%

(C) 4%

(D) 5%

Q6. An ideal gas undergoes a thermodynamic process along a closed path shown in the $P - V$ diagram below. The process goes from $A \to B$ (isobaric expansion), $B \to C$ (isochoric cooling), and $C \to A$ along a straight path back to the initial state. What is the net work done by the gas during one complete cycle?



(A) 4 J

(B) 2 J

(C) −2 J

(D) 6 J

Q7. A monochromatic light beam of wavelength $\lambda_0 = 600$ nm in vacuum passes from air into a transparent glass slab having a refractive index of $\mu = 1.5$. What are the wavelength λ and frequency f of the light beam inside the glass medium?

(A) $\lambda = 400$ nm, $f = 5 \times 10^{14}$ Hz

(B) $\lambda = 400$ nm, $f = 3.33 \times 10^{14}$ Hz

(C) $\lambda = 900$ nm, $f = 5 \times 10^{14}$ Hz

(D) $\lambda = 600$ nm, $f = 3.33 \times 10^{14}$ Hz

Q8. A spherical metal raindrop of radius r falls vertically through air under gravity. After traveling a considerable distance, it achieves a constant terminal velocity v. If another raindrop of the same metal but with radius $2r$ falls through the same air, its terminal velocity will be:

(A) $2v$

(B) $4v$

(C) $\sqrt{2}v$

(D) $v/2$

Q9. A variable force $F = (3x^2 + 2x)$ N acts on a small particle moving along the X-axis. Find the total work done by this force in displacing the particle from $x = 1$ m to $x = 3$ m.

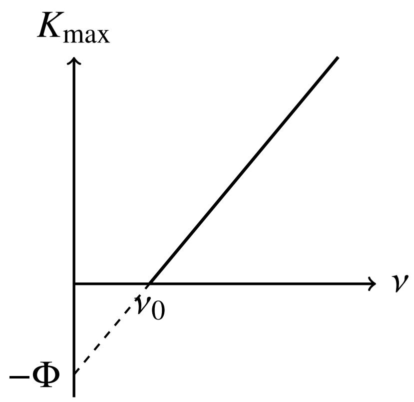
(A) 26 J

(B) 32 J

(C) 34 J

(D) 28 J

Q10. In a photoelectric effect experiment, light of frequency ν is incident on a clean metallic surface. The variation of the maximum kinetic energy K_{max} of the emitted photoelectrons with the incident frequency ν is plotted in the graph below. What physical constant or parameter does the slope of this line represent?



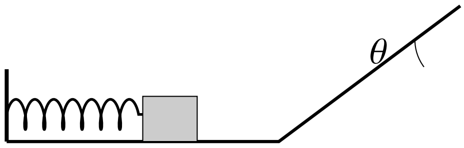
(A) The work function of the metal (Φ)

(B) Plancks constant (h)

(C) The charge of an electron (e)

(D) The threshold wavelength (λ_0)

Q11. A block of mass m is compressed against an ideal horizontal spring of stiffness constant k by a distance x, as shown in the diagram. When the system is released from rest, the spring pushes the block along a frictionless surface until it detaches and launches up a smooth incline making an angle θ with the horizontal. What is the maximum vertical height h reached by the block up the incline?



(A) $\frac{kx^2}{2mg}$

(B) $\frac{kx^2}{2mg\sin\theta}$

(C) $\frac{kx}{mg}$

(D) $\frac{kx^2\sin\theta}{2mg}$

Q12. Water flows steadily through a horizontal tapering pipe with a non-uniform cross-section. At a specific position where the radius of the pipe is R, the fluid speed is v. What will be the fluid speed at a downstream section where the inner pipe radius narrows down to $R/3$?

(A) $3v$

(B) $9v$

(C) $\sqrt{3}v$

(D) $6v$

Q13. If the universal gravitational constant is denoted by G, the speed of light in a vacuum by c, and Plancks constant by h, which of the following expressions correctly combines these constants to form a quantity with the dimensions of length?

(A) $\sqrt{\frac{hG}{c^3}}$

(B) $\sqrt{\frac{hc}{G}}$

(C) $\frac{hG}{c^5}$

(D) $\sqrt{\frac{hG}{c^5}}$

Q14. Two thin co-axial lenses of focal lengths $f_1 = +20$ cm and $f_2 = -40$ cm are kept in direct physical contact with one another. What is the net optical power of this lens combination?

(A) +2.5 D

(B) −2.5 D

(C) +5.0 D

(D) −1.25 D

Q15. An ideal gas is enclosed in a rigid container with fixed walls. If a quantity of heat energy $Q = 500$ J is supplied to the gas from an external source, what are the changes in the work done (W) by the gas and the net internal energy (ΔU) of the system?

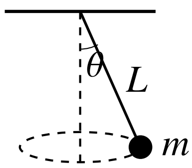
(A) $W = 500$ J, $\Delta U = 0$ J

(B) $W = 0$ J, $\Delta U = 500$ J

(C) $W = 250$ J, $\Delta U = 250$ J

(D) $W = 500$ J, $\Delta U = -500$ J

Q16. A small body of mass m is suspended from a ceiling by a light string of length L. It is set into a horizontal uniform circular motion of radius r, forming a conical pendulum as shown below. If the string makes a steady angle θ with the vertical, what is the tension T in the string?



(A) $mg \sin\theta$

(B) $\frac{mg}{\cos\theta}$

(C) $mg\tan\theta$

(D) $\frac{mg}{\sin\theta}$

Q17. The temperature of a uniform solid brass cube is raised from 20°C to 120°C. If the coefficient of linear expansion of brass is $\alpha = 2 \times 10^{-5}$ /°C, what is the fractional change in the volume ($\Delta V/V$) of the cube?

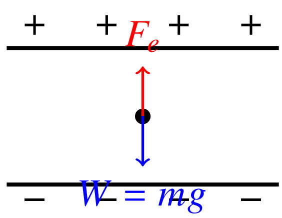
(A) 2×10^{-3}

(B) 4×10^{-3}

(C) 6×10^{-3}

(D) 8×10^{-4}

Q18. An oil drop carries a net charge q and is kept perfectly stationary between two large horizontal parallel plates in a Millikan-style setup. As shown below, an electric field E acts vertically upwards. If the mass of the oil drop is m, what is the explicit relation for its charge q? (Take g as acceleration due to gravity)



(A) $q = \frac{mg}{E}$

(B) $q = \frac{E}{mg}$

(C) $q = mgE$

(D) $q = \frac{mE}{g}$

Q19. A uniform steel rod of length 1.0 m and cross-sectional area 1.0×10^{-4} m^2 is clamped tightly at both ends at a room temperature of 30°C. If the temperature falls to 10°C, find the thermal tension induced in the rod. (Given: $\alpha_{\text{steel}} = 1.2 \times 10^{-5}$ /°C, $Y_{\text{steel}} = 2.0 \times 10^{11}$ N/m^2)

(A) 240 N

(B) 480 N

(C) 120 N

(D) 600 N

Q20. The molar specific heat of an ideal gas at constant pressure is measured to be $C_p = \frac{7}{2}R$. What is the ratio of specific heats ($\gamma = C_p/C_v$) for this gas, and what type of molecular structure does it correspond to?

(A) $\gamma = 1.40$, Diatomic

(B) $\gamma = 1.67$, Monatomic

(C) $\gamma = 1.33$, Polyatomic

(D) $\gamma = 1.25$, Diatomic

Q21. A satellite is orbiting the Earth in a stable circular track very close to the planetary surface. If the acceleration due to gravity at the surface is g and the radius of the Earth is R, what is the orbital speed v_0 of the satellite?

(A) $\sqrt{2gR}$

(B) $\sqrt{gR}$

(C) $\sqrt{\frac{gR}{2}}$

(D) gR

Q22. A point object is placed along the principal axis of a thin convex lens of focal length $f = 15$ cm at a distance of 30 cm from the optical center. What is the nature and magnification (m) of the image formed?

(A) Real, $m = -1$

(B) Virtual, $m = +1$

(C) Real, $m = -2$

(D) Virtual, $m = +2$

Q23. A small water tank is filled with a transparent liquid up to a real height of $h = 12$ cm. When viewed from directly above in air, a tiny scratch on the bottom container surface appears to be raised up by a vertical apparent shift of 3 cm. What is the refractive index of the liquid?

(A) 1.50

(B) 1.60

(C) 1.25

(D) 1.33

Q24. The photon intensity of a light source illuminating a solar photovoltaic cell is doubled while keeping the frequency of the incident radiation strictly constant above the threshold value. How does this modification affect the maximum kinetic energy of emitted electrons and the resulting short-circuit photocurrent?

(A) Max KE doubles; photocurrent stays the same.

(B) Both Max KE and photocurrent are doubled.

(C) Max KE stays the same; photocurrent doubles.

(D) Max KE stays the same; photocurrent increases four-fold.

Q25. A heavy container holds an ideal liquid under high pressure. A small orifice is punched out at a depth h below the free top surface of the liquid. If the atmospheric pressure outside is neglected, what is the speed of efflux of the liquid discharging from the orifice?

(A) $g\sqrt{h}$

(B) $\sqrt{2gh}$

(C) $2gh$

(D) $\sqrt{gh}$

Section–B — 5 Questions × 2 Marks Each (No Negative Marking) [One or More Correct]

Q26. An object of mass m is launched vertically upwards from the surface of a planet with an initial speed equal to the escape velocity v_e. Which of the following statements are completely correct regarding its subsequent mechanical motion?

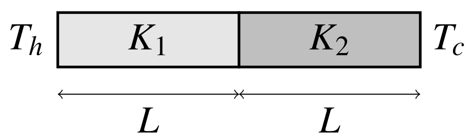
(A) The total mechanical energy of the object-planet system is exactly zero at all points.

(B) The object will come to rest at an infinite distance from the planet.

(C) The initial kinetic energy allocated is equal to the magnitude of its initial gravitational potential energy.

(D) The object will move with a uniform, non-zero constant terminal speed at deep infinity.

Q27. A composite bar is made by joining two structural rods of identical lengths L and identical cross-sectional areas $Aend-to-endinaseriesconfiguration.Thethermalcond$ and K_2 respectively, as depicted below. The outer faces are maintained at constant temperatures T_h and T_c ($T_h > T_c$). Under steady-state conditions, which of the following expressions are true?



(A) The equivalent thermal conductivity of the compound bar is $K_{\text{eq}} = \frac{2K_1K_2}{K_1+K_2}$.

(B) The rate of heat flow through both sections must be identical.

(C) The interface temperature is uniquely given by $T_i = \frac{K_1T_h+K_2T_c}{K_1+K_2}$.

(D) The equivalent thermal resistance is the sum of individual thermal resistances.

Q28. A particle moves under the action of a conservative force field. Which of the following mathematical statements are unconditionally true for its total mechanical motion?

(A) The total mechanical energy (Kinetic + Potential) remains conserved.

(B) The work done by the force along any closed trajectory loop is identically zero.

(C) The force can be written as the negative gradient of a scalar potential function, $\vec{F} = -\vec{\nabla}U$.

(D) The work done depends explicitly on the specific path taken between the initial and final positions.

Q29. An ideal gas is contained within a cylinder fitted with a frictionless piston. The gas is taken from state 1 to state 2 along two distinctly different thermodynamic pathways, Path A and Path B. Which of the following statements are correct regarding the physical parameters of these processes?

(A) The change in internal energy ΔU is identical for both Path A and Path B.

(B) The work done W by the gas must be the same for both paths.

(C) The net heat exchanged Q depends on the specific path chosen.

(D) Internal energy is a state function, whereas heat and work are path functions.

Q30. According to Einsteins photoelectric equation, when a metallic surface is exposed to electromagnetic radiation, which of the following observations are fundamentally accurate?

(A) There is no time lag between the arrival of light radiation and the emission of photoelectrons.

(B) The stopping potential depends linearly on the frequency of the incident radiation.

(C) Photoelectric emission occurs even if the incident light frequency is lower than the threshold frequency, provided intensity is extremely high.

(D) The maximum velocity of emitted electrons depends only on the intensity of light.

Detailed Solutions

Q1.

Solution

Concept:
The threshold of motion for an object resting on a rough surface is dictated by the maximum value of static friction. Once the applied horizontal force exceeds this threshold, the object begins moving, and the resisting force transitions from static friction to kinetic friction, which is typically lower.

Solution:

(a) The normal reaction force acting on the block is given by $N = mg = 2 \times 10 = 20$ N.

(b) The maximum static frictional force preventing motion is $f_{s,\max} = \mu_s N = 0.4 \times 20 = 8$ N.

(c) The horizontal force applied to the block at time t is expressed as $F = 4t$. At $t = 3$ s, the magnitude of this force reaches $F = 4 \times 3 = 12$ N.

(d) Since the applied force (12 N) is strictly greater than the maximum limiting static friction (8 N), the block is in motion at this instant.

(e) During active motion, the friction opposing the acceleration is the kinetic friction: $f_k = \mu_k N = 0.3 \times 20 = 6$ N.

(f) Applying Newtons second law of motion along the horizontal axis yields the net force equation: $F - f_k = ma$.

(g) Substituting the known values into the equation gives $12 - 6 = 2a$, which simplifies to $6 = 2a$. Solving for acceleration results in $a = 3.0$ m/s^2.

Final Answer: The acceleration of the block at three seconds is 3.0 m/s^2.

Answer: (A)

Go Back to Question 1

Q2.

Solution

Concept:
Total internal reflection is a phenomenon that occurs when a light wave travelling through an optically denser medium strikes the boundary of an optically rarer medium at an angle of incidence greater than a specific critical angle characteristic of the interface.

Solution:

(a) For total internal reflection to occur at the boundary between the core and the cladding, the angle of incidence inside the core must be greater than or equal to the critical angle θ_c.

(b) The mathematical relationship governing the critical angle is derived from Snells law and is written as $\sin\theta_c = n_2/n_1$.

(c) According to the problem constraints, total internal reflection occurs at an angle of incidence of 72°, meaning that $72° \geq \theta_c$, or equivalently, $\sin 72° \geq \sin\theta_c$.

(d) Substituting the expression for the critical angle into this inequality yields $\sin 72° \geq n_2/n_1$.

(e) Isolating the refractive index of the cladding gives the upper limit inequality: $n_2 \leq n_1 \sin 72°$.

(f) Given that the core index $n_1 = 1.52$ and $\sin 72° \approx 0.951$, the maximum permissible cladding index calculation becomes $n_2 = 1.52 \times 0.951 = 1.4455$.

(g) To satisfy the condition, the maximum index among the options without exceeding this value is approximately 1.41.

Final Answer: The maximum permissible refractive index of the cladding material is 1.41.

Answer: (A)

Go Back to Question 2

Q3.

Solution

Concept:

When a symmetric body rolls down a slope without experiencing any relative sliding at the point of contact, its overall energy is split into two components: translational kinetic energy of the center of mass and rotational kinetic energy about the center of mass.

Solution:

(a) The translational kinetic energy of the rolling solid marble is expressed by the classical mechanical equation $K_t = \frac{1}{2}Mv^2$.

(b) The rotational kinetic energy of the marble is expressed by $K_r = \frac{1}{2}I\omega^2$, where I is the moment of inertia and ω is the angular velocity.

(c) A solid marble is geometrically a uniform solid sphere, which means its moment of inertia about its central axis is $I = \frac{2}{5}MR^2$.

(d) Since the marble is rolling smoothly without slipping, its linear velocity and angular velocity are locked in the relation $v = R\omega$, or $\omega = v/R$.

(e) Substituting these values into the rotational energy expression gives $K_r = \frac{1}{2}(\frac{2}{5}MR^2)(v/R)^2 = \frac{1}{5}Mv^2$.

(f) The total kinetic energy is the sum of both parts: $K_{\text{total}} = K_t + K_r = \frac{1}{2}Mv^2 + \frac{1}{5}Mv^2 = \frac{7}{10}Mv^2$.

(g) The desired rotational fraction is $K_r/K_{\text{total}} = (\frac{1}{5}Mv^2)/(\frac{7}{10}Mv^2) = \frac{2}{7}$.

Final Answer: The fraction of total kinetic energy associated with rotational motion is 2/7.

Answer: (B)

Go Back to Question 3

Q4.

Solution

Concept:
A multi-body system connected by an inextensible string passing over a frictionless pulley moves with a uniform acceleration. The internal tension in the string can be resolved by applying Newtons laws of motion to each body independently using free-body diagrams.

Solution:

(a) Let the common acceleration of the connected masses be a and the tension pulling along the length of the light string be T.

(b) For the mass m_1 on the horizontal frictionless surface, the only horizontal force acting along the line of motion is the tension, giving the equation $T = m_1 a$.

(c) For the hanging mass m_2, gravity pulls downward while the string tension opposes it. The equation of motion is $m_2 g - T = m_2 a$.

(d) Adding the two equations eliminates the internal tension force, yielding $m_2 g = (m_1 + m_2)a$.

(e) Rearranging for the systemic acceleration gives the standard expression $a = \frac{m_2 g}{m_1 + m_2}$.

(f) Substituting the values ($m_1 = 3$ kg, $m_2 = 2$ kg, $g = 10$ m/s^2) yields an acceleration of $a = \frac{2 \times 10}{3+2} = 4$ m/s^2.

(g) Substituting this back into the first equation to calculate the tension gives $T = 3 \times 4 = 12$ N.

Final Answer: The magnitude of the tension in the string is 12 N.

Answer: (A)

Go Back to Question 4

Q5.

Solution

Concept:
When calculating errors in computed quantities derived from experimental observations, the fractional errors of independent measurements compound based on the mathematical powers to which they are raised in the underlying formula.

Solution:

(a) The volume V of a solid cylinder of radius R and length L is expressed by the geometric formula $V = \pi R^2 L$.

(b) Taking the natural logarithm of both sides of the formula yields the broken-up relation $\ln V = \ln \pi + 2 \ln R + \ln L$.

(c) Differentiating both sides to find the maximum relative fractional error leads to the expression $\frac{\Delta V}{V} = 2\frac{\Delta R}{R} + \frac{\Delta L}{L}$.

(d) The constant term π drops out because it is an exact mathematical value with zero measurement uncertainty.

(e) Given parameters are $R = 2.00$ cm, $\Delta R = 0.02$ cm, $L = 10.0$ cm, and $\Delta L = 0.1$ cm.

(f) Substituting these values gives the calculation $\frac{\Delta V}{V} = 2\left(\frac{0.02}{2.00}\right) + \frac{0.1}{10.0} = 2(0.01) + 0.01 = 0.03$.

(g) Multiplying by one hundred percent gives the final maximum percentage error in volume as $0.03 \times 100 = 3\%$.

Final Answer: The maximum percentage error in the calculated volume is 3%.

Answer: (B)

Go Back to Question 5

Q6.

Solution

Concept:
In a indicator diagram plotting pressure against volume, the net mechanical work done by an ideal gas completing a closed cycle is equal to the geometric area enclosed by the cyclic path.
Solution:

(a) The given cyclic process forms a right-angled triangle in the $P - V$ coordinate space, bounded by states $A(1, 3)$, $B(3, 3)$, and $C(3, 1)$.

(b) The work done along the cyclic loop can be found by evaluating the enclosed area of triangle ABC.

(c) The formula for the area of a right-angled triangle is given by Area $= \frac{1}{2} \times$ base $\times$ height.

(d) The length of the horizontal base line segment AB along the volume axis is $V_B - V_A = 3 - 1 = 2$ m^3.

(e) The length of the vertical height line segment BC along the pressure axis is $P_B - P_C = 3 - 1 = 2$ N/m^2.

(f) Substituting these dimensions into the area formula gives Work $= \frac{1}{2} \times 2 \times 2 = 2$ J.

(g) Since the path proceeds in a clockwise direction in the $P - V$ plane, the net work performed by the gas is thermodynamically positive.

Final Answer: The net work done by the gas during one complete cycle is 2 J.

Answer: (B)

Go Back to Question 6

Q7.

Solution

Concept:
When an electromagnetic light wave moves across a boundary separating media of different optical densities, its speed and wavelength change proportionally due to refraction, whereas its frequency remains completely unchanged.

Solution:

(a) The frequency of light is determined entirely by its source and does not shift when entering a new medium, so $f_{\text{glass}} = f_{\text{vacuum}}$.

(b) The frequency in a vacuum is calculated using the relation $f = c/\lambda_0$.

(c) Given the speed of light $c = 3 \times 10^8$ m/s and wavelength $\lambda_0 = 600 \times 10^{-9}$ m, the frequency is $f = \frac{3\times10^8}{600\times10^{-9}} = 5 \times 10^{14}$ Hz.

(d) The modified wavelength of the light beam inside the transparent glass medium depends on the refractive index and shrinks according to the formula $\lambda = \lambda_0/\mu$.

(e) Substituting the initial vacuum wavelength and the medium index gives the calculation $\lambda = 600 \text{ nm}/1.5 = 400$ nm.

(f) Therefore, inside the glass slab, the wave parameters settle at a wavelength of 400 nm and a frequency of 5×10^{14} Hz.

Final Answer: The wavelength and frequency inside the medium are 400 nm and $5 \times 10^{14} Hz$.

Answer: (A)

Go Back to Question 7

Q8.

Solution

Concept:
A body falling through a viscous fluid experiences a drag force. When this fluid resistance balances the downward pull of gravity, the net acceleration becomes zero, and the body descends at a steady rate known as terminal velocity.

Solution:

(a) Stokes law dictates that the viscous drag force acting on a small falling sphere of radius r moving at speed v is given by $F_d = 6\pi\eta r v$.

(b) At terminal equilibrium, the downward gravitational force minus buoyancy matches this drag force: $6\pi\eta r v = \frac{4}{3}\pi r^3(\rho - \sigma)g$.

(c) Isolating the terminal velocity parameter reveals the proportion $v = \frac{2r^2(\rho-\sigma)g}{9\eta}$.

(d) This formula demonstrates that the terminal velocity of a sphere falling through a given viscous fluid is directly proportional to the square of its radius, or $v \propto r^2$.

(e) Let the initial raindrop have radius $r_1 = r$ and terminal speed $v_1 = v$. The second drop has a radius $r_2 = 2r$.

(f) Setting up a ratio for the secondary terminal velocity yields $\frac{v_2}{v_1} = \left(\frac{r_2}{r_1}\right)^2 = \left(\frac{2r}{r}\right)^2 = 4$.

(g) Solving for the new velocity yields $v_2 = 4v$.

Final Answer: The terminal velocity of the second raindrop will be 4v.

Answer: (B)

Go Back to Question 8

Q9.

Solution

Concept:
When a force varies as a function of position along the path of motion, the total mechanical work performed cannot be calculated by simple multiplication and must instead be evaluated using definite integration.

Solution:

(a) The differential work element dW performed during an infinitesimal displacement dx along the X-axis is defined as $dW = F \cdot dx$.

(b) To calculate the total work done over a finite displacement interval, we integrate the force function between the lower and upper spatial limits: $W = \int_{x_1}^{x_2} F\, dx$.

(c) Substituting the given force function $F = 3x^2 + 2x$ and the limits $x_1 = 1$ m to $x_2 = 3$ m yields $W = \int_1^3 (3x^2 + 2x)\, dx$.

(d) Finding the antiderivative of each term gives the integrated expression $W = \left[x^3 + x^2\right]_1^3$.

(e) Evaluating this expression at the upper boundary limit of three gives $(3^3 + 3^2) = 27 + 9 = 36$.

(f) Evaluating this expression at the lower boundary limit of one gives $(1^3 + 1^2) = 1 + 1 = 2$.

(g) Subtracting the lower bound value from the upper bound value yields the total work: $W = 36 - 2 = 34$ J.

Final Answer: The total work done by this force is 34 J.

Answer: (C)

Go Back to Question 9

Q10.

Solution

Concept:
Einsteins photoelectric equation establishes a linear relationship between the maximum kinetic energy of ejected photoelectrons and the frequency of the incident light source striking a clean metal surface.

Solution:

(a) The governing equation formulated by Einstein is written as $K_{\text{max}} = h\nu - \Phi$, where h is Plancks constant, ν is the incident frequency, and Φ is the work function.

(b) Comparing this expression to the standard algebraic equation of a straight line, $y = mx + c$, lets us identify corresponding coordinate parameters.

(c) The dependent variable plotted on the vertical Y-axis is the maximum kinetic energy (K_{max}), while the independent variable on the horizontal X-axis is the frequency (ν).

(d) The constant term representing the vertical intercept on the Y-axis corresponds directly to the negative work function ($-\Phi$).

(e) The horizontal intercept where the line crosses the frequency axis represents the threshold frequency (ν_0).

(f) The multiplier coefficient attached to the independent variable ν is the slope of the linear plot.

(g) Therefore, the slope of the line is a universal constant equal to Plancks constant (h), independent of the target metal type.

Final Answer: The slope of this line represents Plancks constant.

Answer: (B)

Go Back to Question 10

Q11.

Solution

Concept:

The total mechanical energy of an isolated conservative system remains constant throughout its motion. When a compressed spring releases a mass on a frictionless surface, its elastic potential energy converts entirely into kinetic energy, which then converts into gravitational potential energy as the block ascends a smooth incline.

Solution:

(a) Let the reference level for gravitational potential energy be the initial horizontal frictionless surface where the spring is situated.

(b) When the block of mass m is compressed against the ideal spring by a distance x, the initial energy stored in the system is purely elastic potential energy given by $E_i = \frac{1}{2}kx^2$.

(c) As the block is released from rest, the spring expands and pushes the block forward, completely converting its stored elastic energy into translational kinetic energy at the moment of detachment.

(d) The block then moves along the smooth horizontal track and climbs up the smooth incline where its kinetic energy is gradually converted into gravitational potential energy.

(e) At the maximum vertical height h, the block momentarily comes to rest, meaning its final kinetic energy is exactly zero.

(f) The final mechanical energy of the block-Earth system consists entirely of gravitational potential energy expressed as $E_f = mgh$.

(g) Equating the initial and final mechanical energy gives $\frac{1}{2}kx^2 = mgh$. Solving this algebraic expression for the height yields $h = \frac{kx^2}{2mg}$.

Final Answer: The maximum vertical height reached by the block up the incline is kx$^2\frac{}{2mg.}$

Answer: (A)

Go Back to Question 11

Q12.

Solution

Concept:
For an incompressible, non-viscous fluid undergoing steady, streamline flow through a conduit of variable cross-section, the total mass flow rate remains constant at every point along the channel. This physical principle is mathematically formulated as the continuity equation.
Solution:

(a) The continuity equation for steady fluid flow dictates that the product of the cross-sectional area of the pipe and the fluid velocity must remain invariant at all positions, giving $A_1 v_1 = A_2 v_2$.

(b) For a cylindrical pipe with a circular cross-section, the internal area is directly related to its inner radius R by the geometric formula $A = \pi R^2$.

(c) At the first upstream position, the radius of the pipe is given as $R_1 = R$ and the corresponding fluid velocity is given as $v_1 = v$. Thus, the area is $A_1 = \pi R^2$.

(d) At the downstream section, the pipe narrows down to a smaller radius given by $R_2 = \frac{R}{3}$.

(e) The modified cross-sectional area at this narrow section is calculated as $A_2 = \pi R_2^2 = \pi \left(\frac{R}{3}\right)^2 = \frac{\pi R^2}{9} = \frac{A_1}{9}$.

(f) Substituting these structural expressions back into the continuity equation yields the relation $A_1 v = \left(\frac{A_1}{9}\right) v_2$.

(g) Canceling out the common area term A_1 from both sides of the equation gives the downstream fluid speed as $v_2 = 9v$.

Final Answer: The fluid speed at the downstream section is 9v.

Answer: (B)

Go Back to Question 12

Q13.

Solution

Concept:
Dimensional analysis serves as a powerful mathematical tool to establish functional relationships between different physical quantities by matching their fundamental dimensions of mass, length, and time. Planck length represents a fundamental scale derived from universal constants.

Solution:

(a) Let us express the fundamental dimensions of the given universal constants. The speed of light in a vacuum c has dimensions of velocity, written as $[c] = [LT^{-1}]$.

(b) Newtons universal gravitational constant G is extracted from the gravitational force law, giving its dimensions as $[G] = [M^{-1}L^3T^{-2}]$.

(c) Plancks constant h relates the energy of a photon to its frequency via $E = h\nu$, yielding the dimensional formula $[h] = [ML^2T^{-1}]$.

(d) We seek a combination of the form $L \propto h^x G^y c^z$. Substituting the dimensional formulas gives $[L] = [ML^2T^{-1}]^x[M^{-1}L^3T^{-2}]^y[LT^{-1}]^z$.

(e) Grouping the fundamental units together yields $[L] = [M^{x-y}L^{2x+3y+z}T^{-x-2y-z}]$.

(f) Equating the exponents on both sides gives three simultaneous equations: $x - y = 0$, $2x + 3y + z = 1$, and $-x - 2y - z = 0$.

(g) Solving this system yields $x = \frac{1}{2}$, $y = \frac{1}{2}$, and $z = -\frac{3}{2}$. Substituting these values gives the expression $\sqrt{\frac{hG}{c^3}}$.

Final Answer: The correct combination with dimensions of length is $\sqrt{\frac{hG}{c^3}}$.

Answer: (A)

Go Back to Question 13

Q14.

Solution

Concept:
The optical power of a thin lens is defined as the reciprocal of its focal length measured in meters, representing its ability to converge or diverge light. When multiple thin lenses are placed in direct physical contact, their individual optical powers add algebraically.

Solution:

(a) The individual optical power P of any thin lens is mathematically related to its focal length f by the definition $P = \frac{1}{f}$, where f must be expressed in meters.

(b) The focal length of the first convex lens is given as $f_1 = +20$ cm $= +0.2$ m. Its optical power is $P_1 = \frac{1}{+0.2} = +5.0$ Diopters.

(c) The focal length of the second concave lens is given as $f_2 = -40$ cm $= -0.4$ m. Its optical power is $P_2 = \frac{1}{-0.4} = -2.5$ Diopters.

(d) For co-axial thin lenses kept in close contact, the net effective optical power P_{net} of the combination is equal to the direct algebraic sum of their powers, written as $P_{net} = P_1 + P_2$.

(e) Substituting the calculated values into the summation expression yields $P_{net} = (+5.0 \text{ D}) + (-2.5 \text{ D}) = +2.5$ Diopters.

(f) Alternatively, the combined focal length can be found via $\frac{1}{f_{net}} = \frac{1}{20} - \frac{1}{40} = \frac{1}{40}$ cm^{-1}, which gives $f_{net} = +40$ cm $= +0.4$ m. Power is then $P_{net} = \frac{1}{+0.4} = +2.5$ D.

Final Answer: The net optical power of this lens combination is +2.5 D.

Answer: (A)

Go Back to Question 14

Q15.

Solution

Concept:

The first law of thermodynamics states that the net heat energy supplied to a thermodynamic system is split between changing its internal molecular energy and the external mechanical work performed by the system on its surroundings.

Solution:

(a) The mathematical formulation of the first law of thermodynamics is written as $Q = \Delta U + W$, where Q is the heat added, ΔU is the internal energy change, and W is the work done.

(b) The problem states that the ideal gas is enclosed inside a perfectly rigid container with fixed walls.

(c) In thermodynamics, the boundary work performed by a gas during any process is related to its volumetric transformation by the integral expression $W = \int P\, dV$.

(d) Because the container is completely rigid and its walls are immovably fixed, the total volume V of the ideal gas remains strictly constant, meaning the differential volume change is $dV = 0$.

(e) Since there is absolutely no change in volume ($dV = 0$), the external mechanical work done by the gas is identically zero ($W = 0$ J).

(f) Substituting this condition back into the first law equation simplifies the expression to $Q = \Delta U$.

(g) Given that a quantity of heat energy $Q = 500$ J is supplied, the change in the internal energy is $\Delta U = 500$ J.

Final Answer: The changes are W = 0 J and $\Delta U = 500J$.

Answer: (B)

Go Back to Question 15

Q16.

Solution

Concept:
A conical pendulum consists of a mass moving at a constant speed along a horizontal circle. The mass is suspended by a string, which sweeps out a conical surface. The forces acting on the mass are resolved using a free-body diagram in an inertial frame.

Solution:

(a) Let us analyze the forces acting on the small suspended body of mass m at any instant during its uniform circular trajectory.

(b) Two principal forces act on the mass: the downward gravitational force $W = mg$ and the tension force T pulling along the orientation of the string toward the ceiling support.

(c) The string makes a steady angle θ with the vertical line. We can resolve the tension vector T into two perpendicular geometric components.

(d) The vertical component of the tension acts directly upward and is given by $T\cos\theta$, while the horizontal component points toward the center of the circular track and is given by $T\sin\theta$.

(e) Since there is absolutely no vertical acceleration or motion along the vertical axis, the forces in this direction must be in perfect equilibrium, giving $T\cos\theta = mg$.

(f) The horizontal component $T\sin\theta$ provides the necessary centripetal force to maintain the circular path, written as $T\sin\theta = \frac{mv^2}{r}$.

(g) From the vertical equilibrium equation, we can directly isolate the tension parameter, yielding $T = \frac{mg}{\cos\theta}$.

Final Answer: The tension T in the string is mg$\frac{}{\cos\theta.}$

Answer: (B)

Go Back to Question 16

Q17.

Solution

Concept:

When the temperature of a solid object is raised, its average molecular separation increases, leading to macroscopic thermal expansion. For isotropic solid materials, the volumetric expansion coefficient is directly proportional to its linear expansion coefficient.

Solution:

(a) Let the initial volume of the uniform solid brass cube at the starting temperature be V.

(b) The temperature of the solid brass cube is increased from an initial value of $T_1 = 20°C$ to a final value of $T_2 = 120°C$.

(c) The net change in the temperature of the material is calculated as $\Delta T = T_2 - T_1 = 120 - 20 = 100°C$.

(d) The mathematical relationship governing volumetric thermal expansion is expressed as $\Delta V = V\gamma\Delta T$, where γ is the coefficient of volume expansion.

(e) For a uniform, isotropic solid substance like brass, the volume expansion coefficient is exactly three times the linear expansion coefficient, written as $\gamma = 3\alpha$.

(f) Given that the coefficient of linear expansion is $\alpha = 2 \times 10^{-5}$ /°C, the volumetric coefficient is $\gamma = 3 \times (2 \times 10^{-5}) = 6 \times 10^{-5}$ /°C.

(g) Rearranging the thermal expansion formula to find the fractional change yields $\frac{\Delta V}{V} = \gamma\Delta T = (6 \times 10^{-5}\ /°C) \times 100°C = 6 \times 10^{-3}$.

Final Answer: The fractional change in the volume of the cube is 6×10^{-3}.

Answer: (C)

Go Back to Question 17

Q18.

Solution

Concept:
An object suspended inside a uniform electric field experiences an electrostatic force. For the object to remain perfectly stationary in mid-air, the upward electrostatic force must precisely balance the downward gravitational pull acting on its mass.

Solution:

(a) Let us analyze the forces acting on the charged oil drop suspended between the large parallel plates. The drop has a mass m and carries a net charge q.

(b) The downward force acting on the drop due to gravity is its weight, expressed as $F_g = mg$.

(c) The uniform electric field E acts vertically upwards. The electrostatic force experienced by a charge q inside an electric field is given by $F_e = qE$.

(d) According to the provided vector diagram, the electric force F_e is directed vertically upwards, opposing the downward gravitational pull.

(e) For the oil drop to be kept perfectly stationary and in static equilibrium, the net force acting on it along the vertical axis must be zero.

(f) Setting the magnitude of the upward electrostatic force equal to the downward gravitational weight yields the equilibrium equation $qE = mg$.

(g) Isolating the explicit relation for the charge parameter q by dividing both sides of the equation by the electric field intensity gives $q = \frac{mg}{E}$.

Final Answer: The explicit relation for its charge is q = mg$\overline{E.}$

Answer: (A)

Go Back to Question 18

Q19.

Solution

Concept:
When a solid rod is tightly clamped at both ends, it is prevented from expanding or contracting during temperature changes. A drop in temperature causes the material to attempt to contract, inducing mechanical thermal stress and tension within the rod.

Solution:

(a) The structural parameters of the steel rod are length $L = 1.0$ m and cross-sectional area $A = 1.0 \times 10^{-4}$ m^2.

(b) The ambient temperature drops from an initial value of $T_1 = 30°C$ to a final value of $T_2 = 10°C$, giving a net temperature change of $\Delta T = 30 - 10 = 20°C$.

(c) If the rod were free to move, the thermal strain contraction would be given by the linear expansion formula as $\frac{\Delta L}{L} = \alpha \Delta T$.

(d) Because the ends are rigidly clamped, an internal mechanical stress develops to counteract this strain. Youngs modulus is defined as $Y = \frac{\text{Stress}}{\text{Strain}} = \frac{F/A}{\alpha \Delta T}$.

(e) Rearranging this mechanical equation allows us to find the thermal tension force induced inside the rod: $F = Y A \alpha \Delta T$.

(f) Substituting the given values yields $F = (2.0 \times 10^{11}) \times (1.0 \times 10^{-4}) \times (1.2 \times 10^{-5}) \times 20$.

(g) Simplifying the exponential values step-by-step results in $F = 2.0 \times 1.0 \times 1.2 \times 20 \times 10^2 = 48 \times 10^1 = 480$ N.

Final Answer: The thermal tension induced in the rod is 480 N.

Answer: (B)

Go Back to Question 19

Q20.

Solution

Concept:
The molar specific heat capacities of an ideal gas at constant pressure and constant volume are linked by Mayers relation. The ratio of these specific heats, denoted by gamma, reflects the active internal degrees of freedom and reveals the molecular structure of the gas.
Solution:

(a) Mayers thermodynamic relation states that the difference between the molar specific heat at constant pressure and constant volume equals the universal gas constant, $C_p - C_v = R$.

(b) Rearranging Mayers relation allows us to calculate the molar specific heat at constant volume: $C_v = C_p - R$.

(c) The problem states that the constant-pressure specific heat capacity is measured to be $C_p = \frac{7}{2}R$.

(d) Substituting this value into the equation yields $C_v = \frac{7}{2}R - R = \frac{5}{2}R$.

(e) The ratio of specific heats, gamma, is defined as $\gamma = \frac{C_p}{C_v}$. Substituting the calculated values gives $\gamma = \frac{(7/2)R}{(5/2)R} = \frac{7}{5} = 1.40$.

(f) According to the kinetic theory of gases, a specific heat ratio of $\gamma = 1.40$ (or $C_v = \frac{5}{2}R$) corresponds to five active degrees of freedom.

(g) This matches a linear diatomic molecular structure, which has three translational and two rotational degrees of freedom at standard room temperatures.

Final Answer: The ratio of specific heats is $\gamma = 1.40, which corresponds to a Diatomic gas.$

Answer: (A)

Go Back to Question 20

Q21.

Solution

Concept:
A satellite moving in a stable circular orbit around a planet is maintained by the gravitational force acting as a centripetal force. For an orbit located extremely close to the planetary surface, the orbital radius can be approximated by the radius of the planet itself, and the acceleration due to gravity is equal to its surface value.

Solution:

(a) Let the mass of the planet Earth be M, the mass of the satellite be m, and the radius of the Earth be R.

(b) The gravitational force exerted by the Earth on the satellite provides the necessary centripetal force required to maintain its circular path, which gives $\frac{GMm}{r^2} = \frac{mv_0^2}{r}$.

(c) Since the satellite orbits very close to the planetary surface, the orbital radius r is approximately equal to the radius of the Earth ($r \approx R$).

(d) Substituting this approximation into the force balance equation simplifies it to $\frac{GMm}{R^2} = \frac{mv_0^2}{R}$.

(e) Canceling the mass of the satellite m from both sides yields the expression for the squared orbital velocity: $v_0^2 = \frac{GM}{R}$.

(f) The acceleration due to gravity g at the surface of the Earth is defined by Newtons gravitational law as $g = \frac{GM}{R^2}$, which can be rewritten as $gR = \frac{GM}{R}$.

(g) Comparing these equations allows us to substitute gR for the velocity term, giving $v_0^2 = gR$, which simplifies to $v_0 = \sqrt{gR}$.

Final Answer: The orbital speed of the satellite is $\sqrt{gR}$.

Answer: (B)

Go Back to Question 21

Q22.

Solution

Concept:
The formation of images by a thin convex lens is described by the thin lens formula, which sets a relationship between the focal length, the object distance, and the resulting image distance. The linear magnification is defined as the ratio of the image distance to the object distance.
Solution:

(a) According to standard Cartesian sign convention, the focal length of the convex lens is positive ($f = +15$ cm), and the object distance is negative ($u = -30$ cm).

(b) The thin lens equation is expressed as $\frac{1}{v} - \frac{1}{u} = \frac{1}{f}$, where v is the unknown image distance.

(c) Substituting the values into the thin lens formula yields the algebraic expression $\frac{1}{v} - \frac{1}{-30} = \frac{1}{15}$, which simplifies to $\frac{1}{v} + \frac{1}{30} = \frac{1}{15}$.

(d) Isolating the image term gives $\frac{1}{v} = \frac{1}{15} - \frac{1}{30} = \frac{2-1}{30} = \frac{1}{30}$, which determines that the image distance is $v = +30$ cm.

(e) The positive sign of the image distance indicates that the image is formed on the opposite side of the lens, meaning it is a real image.

(f) The formula for the linear magnification of a thin lens is given by $m = \frac{v}{u}$.

(g) Substituting the distances into the magnification formula gives $m = \frac{30}{-30} = -1$. The negative sign indicates that the real image is inverted and equal in size.

Final Answer: The image is Real with a magnification of -1.

Answer: (A)

Go Back to Question 22

Q23.

Solution

Concept:

When light travels from an optically denser medium into an optically rarer medium like air, it refracts away from the normal. This bending makes objects immersed in the liquid appear closer to the surface than they actually are, creating an apparent shift in depth.

Solution:

(a) Let the actual depth of the liquid in the tank be h and the apparent depth viewed from directly above be h'.

(b) The relationship between the true depth, the apparent depth, and the refractive index μ of the liquid is given by the formula $h' = \frac{h}{\mu}$.

(c) The vertical apparent shift d represents the distance by which the scratch appears to be raised up, which is defined as $d = h - h'$.

(d) Substituting the apparent depth formula into the shift equation yields the relationship $d = h\left(1 - \frac{1}{\mu}\right)$.

(e) The problem states that the real height of the liquid is $h = 12$ cm and the vertical apparent shift is $d = 3$ cm.

(f) Substituting these values into the shift equation gives $3 = 12\left(1 - \frac{1}{\mu}\right)$. Dividing both sides by twelve yields $\frac{3}{12} = \frac{1}{4} = 1 - \frac{1}{\mu}$.

(g) Rearranging the terms to isolate the refractive index gives $\frac{1}{\mu} = 1 - \frac{1}{4} = \frac{3}{4}$, which simplifies to $\mu = \frac{4}{3} \approx 1.33$.

Final Answer: The refractive index of the liquid is 1.33.

Answer: (D)

Go Back to Question 23

Q24.

Solution

Concept:
In the photoelectric effect, the maximum kinetic energy of emitted photoelectrons depends exclusively on the frequency of the incident light and the work function of the target metal. The photocurrent, however, depends directly on the total number of photons striking the surface per unit time.

Solution:

(a) According to Einsteins photoelectric equation, the maximum kinetic energy of the emitted electrons is expressed as $K_{\max} = h\nu - \Phi$.

(b) Since the frequency ν of the incident light and the work function Φ of the metallic surface are kept strictly constant, the value of $K_{\max}$ remains entirely unaffected.

(c) The intensity of a light beam at a fixed frequency is directly proportional to the photon flux, which is the total number of photons arriving per second.

(d) Doubling the intensity of the light source means that twice as many photons are incident on the photovoltaic cell every second.

(e) Since each individual photon interacts with exactly one electron in a one-to-one collision, doubling the photon flux doubles the number of photoelectrons ejected per second.

(f) The short-circuit photocurrent is defined as the rate of flow of photoelectrons, meaning it is directly proportional to the number of electrons emitted.

(g) Consequently, doubling the intensity causes the photocurrent to double, while the maximum kinetic energy stays completely unchanged.

Final Answer: The maximum kinetic energy stays the same while the photocurrent doubles.

Answer: (C)

Go Back to Question 24

Q25.

Solution

Concept:
Torricellis law states that the speed of efflux of an ideal, incompressible liquid discharging through a small opening or orifice under the action of gravity is identical to the speed that a single droplet would acquire in falling freely from rest through the same vertical height.

Solution:

(a) Let us apply Bernoullis equation along a streamline connecting the top free surface of the liquid to the exit point of the small orifice.

(b) Bernoullis principle states that the total mechanical energy along a streamline remains constant: $P_1 + \frac{1}{2}\rho v_1^2 + \rho g h_1 = P_2 + \frac{1}{2}\rho v_2^2 + \rho g h_2$.

(c) Let the top surface be position 1, where the liquid is nearly stationary ($v_1 \approx 0$) and located at a reference height $h_1 = h$.

(d) Let the orifice be position 2, located at a height $h_2 = 0$, where the liquid discharges with an efflux speed $v_2 = v$.

(e) Since atmospheric pressure outside is explicitly neglected in this problem, the pressures at both positions are considered equal ($P_1 = P_2 = 0$).

(f) Substituting these boundary conditions into Bernoullis equation simplifies the energy balance to $\rho g h = \frac{1}{2}\rho v^2$.

(g) Canceling out the fluid density ρ and multiplying both sides by two gives $v^2 = 2gh$, which yields the speed of efflux as $v = \sqrt{2gh}$.

Final Answer: The speed of efflux of the liquid discharging from the orifice is $\sqrt{2gh}$.

Answer: (B)

Go Back to Question 25

Q26.

Solution

Concept:
The escape velocity represents the theoretical minimum speed required for an unpowered ballistic body to completely break free from the gravitational pull of a massive planetary system. When a body is launched with this critical velocity from the surface, its total mechanical energy equals zero.

Solution:

(a) Let us evaluate each physical statement regarding the upward vertical motion:

- Statement A: The total mechanical energy E of any closed system is the sum of its kinetic and potential energies. At the launch surface, $E = \frac{1}{2}mv_e^2 - \frac{GMm}{R}$. Since $v_e = \sqrt{\frac{2GM}{R}}$, substituting this speed gives $E = \frac{GMm}{R} - \frac{GMm}{R} = 0$. Because gravity is a conservative force, this total mechanical energy remains zero at every position. This statement is correct.
- Statement B: As the object moves upward, its kinetic energy continuously converts into gravitational potential energy. At an infinite distance, the potential energy approaches zero, which means the kinetic energy must also approach zero. Thus, the body asymptotically comes to rest at infinity. This statement is correct.
- Statement C: The initial kinetic energy is $K_i = \frac{1}{2}mv_e^2 = \frac{GMm}{R}$. The magnitude of the initial gravitational potential energy is $|U_i| = \frac{GMm}{R}$. Therefore, the allocated kinetic energy equals the magnitude of its initial potential energy. This statement is correct.
- Statement D: Since the kinetic energy becomes zero at deep infinity, the object does not retain a non-zero constant terminal speed. This statement is incorrect.

(b) The correct mechanical descriptions are given by statements (A), (B), and (C).

Final Answer: A, B, C

Answer: (A, B, C)

Go Back to Question 26

Q27.

Solution

Concept:
When two uniform conducting rods are joined end-to-end in a series configuration, the rate of heat flow through each section must be identical under steady-state conditions to preserve energy conservation. The equivalent thermal parameters can be derived using an electrical analogy.

Solution:

(a) Let us evaluate each thermodynamic statement under steady-state conditions:

- Statement A: The thermal resistance of a single structural rod is given by $R_{\text{th}} = \frac{L}{KA}$. For a series combination, the total resistance is $R_{\text{eq}} = R_1 + R_2 = \frac{L}{K_1 A} + \frac{L}{K_2 A} = \frac{L}{A}\left(\frac{K_1+K_2}{K_1 K_2}\right)$. The equivalent conductivity K_{eq} for a compound bar of total length $2L$ satisfies $R_{\text{eq}} = \frac{2L}{K_{\text{eq}} A}$, which yields $K_{\text{eq}} = \frac{2K_1 K_2}{K_1+K_2}$. This statement is correct.
- Statement B: Steady-state flow means that heat energy does not accumulate at any junction. Therefore, the rate of heat flow through both sections must be identical. This statement is correct.
- Statement C: Let T_i be the interface temperature. The heat flow equality dictates $\frac{K_1 A(T_h - T_i)}{L} = \frac{K_2 A(T_i - T_c)}{L}$. Simplifying this equality gives $K_1 T_h - K_1 T_i = K_2 T_i - K_2 T_c$, which yields $T_i = \frac{K_1 T_h + K_2 T_c}{K_1 + K_2}$. This statement is correct.
- Statement D: Like electrical resistors connected in series, the equivalent thermal resistance of a compound bar equals the sum of the individual resistances. This statement is correct. 5. All four statements provide completely accurate descriptions of the steady-state thermal system.

Final Answer: A, B, C, D

Answer: (A, B, C, D)

Go Back to Question 27

Q28.

Solution

Concept:
A force field is conservative if the work done in moving a particle between two positions depends only on the initial and final states, remaining completely independent of the path taken. This mechanical property allows for the definition of a scalar potential function.

Solution:

(a) Let us evaluate each mathematical statement regarding conservative forces:

- Statement A: In a conservative force field, any loss of kinetic energy is accompanied by an equal gain in potential energy, ensuring that the total mechanical energy remains conserved throughout the motion. This statement is correct.
- Statement B: If a particle travels along a path that returns to its starting point, the net displacement is zero. Since the work depends only on the endpoints, the work done along any closed trajectory loop is identically zero. This statement is correct.
- Statement C: A conservative force can be mathematically defined as the negative spatial gradient of a scalar potential energy function, expressed as $\vec{F} = -\vec{\nabla}U$. This statement is correct.
- Statement D: The work done by a conservative force is independent of the path taken, meaning this statement is incorrect.

(b) The unconditionally true mathematical descriptions are given by statements (A), (B), and (C).

Final Answer: A, B, C

Answer: (A, B, C)

Go Back to Question 28

Q29.

Solution

Concept:

In thermodynamics, physical parameters are classified as either state functions or path functions. State functions depend exclusively on the current equilibrium state of the system, whereas path functions depend on the specific thermodynamic sequence of steps connecting the states.

Solution:

(a) Let us evaluate each statement regarding the thermodynamic pathways:

- Statement A: Internal energy U is a property that depends solely on the state of the gas. Because both Path A and Path B connect the same initial state 1 to the same final state 2, the change in internal energy $\Delta U = U_2 - U_1$ is identical for both pathways. This statement is correct.
- Statement B: The work done $W = \int P\, dV$ corresponds to the area under the curve on a $P - V$ diagram. Since Path A and Path B trace different curves, the areas under them are different, meaning the work done is not the same. This statement is incorrect.
- Statement C: According to the first law of thermodynamics, $Q = \Delta U + W$. Since the work term W varies between the two tracks while ΔU remains constant, the net heat exchanged Q must depend on the chosen path. This statement is correct.
- Statement D: Internal energy depends only on the coordinates of the state, whereas heat and work characterize the process itself, making them path functions. This statement is correct.

(b) The correct descriptions are given by statements (A), (C), and (D).

Final Answer: A, C, D

Answer: (A, C, D)

Go Back to Question 29

Q30.

Solution

Concept:
Einsteins photoelectric equation treats electromagnetic radiation as a flux of discrete wave-packets called photons. This quantum mechanical framework explains the instantaneous ejection of electrons and why the kinetic energy depends on frequency rather than intensity.
Solution:

(a) Let us evaluate each physical observation based on Einsteins equation:

- Statement A: The photoelectric interaction is a discrete one-to-one collision between an incident photon and a bound conduction electron. Consequently, there is no measurable time lag between the arrival of the radiation and electron emission. This statement is correct.
- Statement B: Einsteins equation is $eV_s = h\nu - \Phi$, which can be rewritten as $V_s = \left(\frac{h}{e}\right)\nu - \frac{\Phi}{e}$. This demonstrates that the stopping potential V_s depends linearly on the frequency ν of the light. This statement is correct.
- Statement C: If the frequency of the incident light is lower than the threshold value ($\nu < \nu_0$), an individual photon lacks the energy required to overcome the work function. No emission occurs, regardless of how high the intensity is. This statement is incorrect.
- Statement D: The maximum velocity of the emitted photoelectrons depends entirely on the incident frequency, while the intensity of light determines only the total number of electrons ejected. This statement is incorrect.

(b) The fundamentally accurate physical observations are given by statements (A) and (B).

Final Answer: A, B

Answer: (A, B)

Go Back to Question 30

Answer Key

Q	Ans	Q	Ans	Q	Ans	Q	Ans	Q	Ans
1	A	2	A	3	B	4	A	5	B
6	B	7	A	8	B	9	C	10	B
11	A	12	B	13	A	14	A	15	B
16	B	17	C	18	A	19	B	20	A
21	B	22	A	23	D	24	C	25	B
26	A, B, C	27	A, B, C, D	28	A, B, C	29	A, C, D	30	A, B