

Applying Newton's second law along the incline: $F - mg \sin(30^\circ) = ma$. Substituting the given values: $F - 5 \times 10 \times (0.5) = 5 \times 1.0$, which yields $F = 30 \text{ N}$.

10. A ball of mass M moves with speed V in the $+x$ -direction. It explodes into two pieces that go off at angles θ_1 and θ_2 , as shown below. (1)

What are the magnitude of the momenta of the two pieces?

[Figure: A diagram shows a ball of mass M moving horizontally to the right along a straight line. At an explosion point, the trajectory branches into two paths: one with mass labeled m_1 moving along an arrow directed upwards and to the right at an angle θ_1 relative to the horizontal line, and another with mass labeled m_2 moving along an arrow directed downwards and to the right at an angle θ_2 relative to the horizontal line.]

- A. $p_1 = \frac{MV \cos \theta_2}{\sin(\theta_1 + \theta_2)}$, and $p_2 = \frac{MV \cos \theta_1}{\sin(\theta_1 + \theta_2)}$ B. ✓ $p_1 = \frac{MV \sin \theta_2}{\sin(\theta_1 + \theta_2)}$, and $p_2 = \frac{MV \sin \theta_1}{\sin(\theta_1 + \theta_2)}$
 C. $p_1 = MV \tan \theta_2$, and $p_2 = MV \tan \theta_1$ D. $p_1 = \frac{MV \cos \theta_2}{\cos(\theta_1 + \theta_2)}$, and $p_2 = \frac{MV \cos \theta_1}{\cos(\theta_1 + \theta_2)}$

Answer: B

Applying the conservation of momentum in both horizontal and vertical directions yields the equations $p_1 \cos \theta_1 + p_2 \cos \theta_2 = MV$ and $p_1 \sin \theta_1 = p_2 \sin \theta_2$. Solving this system for p_1 and p_2 gives the expressions in option B.

11. The rate of change of momentum of the raindrop can be given by $F = ma + u \frac{\Delta m}{\Delta t}$ (1)
 In this expression what does u represent?

- A. ✓ **The velocity of the extra mass added to the raindrop**
 B. The velocity of the raindrop
 C. The velocity of the loss in mass of raindrop
 D. The rate of change of the velocity for combined system

Answer: A

In variable mass systems, the term ' u ' in the equation represents the relative velocity of the entering (or leaving) extra mass with respect to the primary system (the raindrop).

12. Which of the following is equal to the amount of work required to stop a moving object ? (1)
- A. the mass of the object times its acceleration
 B. ✓ **the kinetic energy of the object**
 C. the square of the velocity of the object
 D. the mass of the object times its velocity

Answer: B

According to the work-energy theorem, the work required to bring a moving object to a complete stop is equal in magnitude to its initial kinetic energy.

13. A 1kg roller coaster is acted on by a 4N force over a displacement of 2m in the direction of force and then set free. The roller is moving on a smooth and horizontal surface towards a free end of a spring of constant k , whose other end is fixed on the wall. If the spring is compressed by 20cm to bring the roller coaster to rest, then what is the value of the spring constant? (1)
- A. 100 N/m B. 200 N/m
 C. ✓ **400 N/m** D. 800 N/m

Answer: C

The work done by the force is $W = F \cdot d = 4 \cdot 2 = 8$ J. This is fully converted to kinetic energy and then to elastic potential energy: $0.5 \cdot k \cdot x^2 = 8 \rightarrow 0.5 \cdot k \cdot (0.2)^2 = 8$, which gives $k = 400$ N/m.

14. In which of the following case is no work done by a dissipative force? (1)
- A. When a parachute jump from a plane
 - B. ✓ **For a freely falling object**
 - C. On a racing car that moves in a desert
 - D. When someone slides a box on a horizontal rough surface.

Answer: B

By definition, a 'freely falling object' is only acted upon by gravity, meaning there are no dissipative forces like air resistance or friction acting on it, so no work is done by such forces.

15. Five beads of equal mass are fixed on a rigid light rod that is free to rotate about a frictionless vertical bearing. (1)
The arrangement is such that, four of them are placed at 0.25 m and the fifth one is at 0.5m from the axis of rotation. The rotational kinetic energy is 144J when the beads were rotating with angular speed of 48rad/s. What is the mass of each bead?
- A. ✓ **0.25Kg**
 - B. 0.5Kg
 - C. 0.75 Kg
 - D. 1Kg

Answer: A

The total moment of inertia of the 5 beads of mass m is $I = 4*m*(0.25)^2 + m*(0.5)^2 = 0.5m$. Using $K_{rot} = 0.5*I*\omega^2$: $144 = 0.5*(0.5m)*(48)^2 \rightarrow 144 = 576m$, which gives $m = 0.25$ kg.

16. A thin circular ring of mass M and radius r and moment of inertia Mr^2 is rotating about its axis with a constant (1)
angular velocity ω . Two objects each of mass m , are attached gently to the opposite ends of a diameter of the ring. What would be the angular velocity of the wheel ?
- A. $\frac{\omega M}{(M+m)}$
 - B. $\frac{\omega(M+2m)}{(M+2m)}$
 - C. ✓ $\frac{\omega M}{(M+2m)}$
 - D. $\frac{\omega(M+2m)}{M}$

Answer: C

Using conservation of angular momentum: $I_1*\omega_1 = I_2*\omega_2$. Here, $I_1 = M*r^2$ and $I_2 = M*r^2 + 2*m*r^2 = (M + 2m)*r^2$. Thus, $\omega_2 = \omega*M / (M + 2m)$.

17. In a playing room a turn table of radius 2m has moment of inertia $250Kg\,m^2$ and is rotating about a frictionless (1)
vertical axel. When a boy of mass 50Kg stands near the rim, the system rotates with angular speed 3rad/s. The boy walks towards the center and stands at 1m from the axel. What is the final angular speed of the system?
- A. 3rad/s
 - B. 2.5rad/s
 - C. 5.4rad/s
 - D. ✓ **4.5rad/s**

Answer: D

By conservation of angular momentum, $I_1*\omega_1 = I_2*\omega_2$. The initial moment of inertia is $I_1 = 250 + 50*(2)^2 = 450$ $kg*m^2$. The final moment of inertia is $I_2 = 250 + 50*(1)^2 = 300$ $kg*m^2$. Thus, $\omega_2 = (450 * 3) / 300 = 4.5$ rad/s.

18. Two forces $\vec{F}_1 = 3\hat{i}$ N and $\vec{F}_2 = 4\hat{j}$ N are acting on a particle of mass m . What is the magnitude and direction (1)
of a force that balances the two?
- A. $\vec{F}_{eq} = 7$ N at 127° counterclockwise from $\vec{F}_1$
 - B. ✓ $\vec{F}_{eq} = 5$ N at 143° counterclockwise from $\vec{F}_2$
 - C. $\vec{F}_{eq} = 7$ N at 127° counterclockwise from $\vec{F}_2$
 - D. $\vec{F}_{eq} = 5$ N at 143° counterclockwise from $\vec{F}_1$

Answer: B

The equilibrant force is $F_{eq} = -3\hat{i} - 4\hat{j}$ N, which has a magnitude of 5 N. The angle of F_{eq} with the positive y-axis (F_2) is found using the dot product: $\cos\theta = (F_2 \cdot F_{eq}) / (|F_2||F_{eq}|) = -16/20 = -0.8$, meaning $\theta \approx 143^\circ$ counterclockwise from F_2 .

19. The rod shown in the figure below is uniform and its weight is 2.8 N. The length of the rod is 3.0 m. Two ropes A and B keep the rod in horizontal position. Rope A is 1.0 m from one end and rope B is at the other end of the rope. What is the calculated value of the tension in rope A?

[Figure: A horizontal uniform rod of length 3 m and weight 2.8 N is shown in equilibrium. Two vertical ropes labeled A and B support the rod from above. Rope A is attached at a distance of 1 m from the left end of the rod, as indicated by a horizontal dimension line labeled '1 m'. Rope B is attached at the far right end of the rod. A horizontal dimension line spanning the full length of the rod from the left end to the right end is labeled '3 m'. A downward-pointing vertical arrow at the center of the rod is labeled '2.8 N', representing the weight of the rod.]

23. The direction of heat flow is from:

(1)

- A. high pressure to low pressure
- B. ✓ **high temperature to low temperature**
- C. high density to low density
- D. a point of higher emissivity to lower one

Answer: B

According to the second law of thermodynamics, heat spontaneously flows from a body at a higher temperature to a body at a lower temperature.

24. External force of 220N applied on a piston of a cylinder containing 1.25g of ammonia gas move 10cm as shown in the diagram below. Assuming adiabatic process, what is the rise in temperature of the gas? (Specific heat capacity of ammonia, $c = 2200 \text{ J/Kg } ^\circ\text{K}$)

(1)

[Figure: A horizontal cylinder containing gas with a piston inside. An external force arrow labeled ' $F = 220\text{N}$ ' points to the left against the piston rod. A horizontal dimension below the piston indicates a displacement of '10cm' to the left between dashed reference lines.]

- A. $4 ^\circ\text{K}$
- B. ✓ **$8 ^\circ\text{K}$**
- C. $0.004 ^\circ\text{K}$
- D. $0.008 ^\circ\text{K}$

Answer: B

For an adiabatic process, the work done on the gas increases its internal energy: $\Delta U = W = F \cdot d = 220 \text{ N} \times 0.1 \text{ m} = 22 \text{ J}$. Since $\Delta U = mc\Delta T$, the temperature rise is $\Delta T = \frac{22}{0.00125 \times 2200} = 8 \text{ K}$.

25. Which of the following statement is correct? (Here ρ is the density of an ideal gas, m is the mass of the gas and c is speed of particles)

(1)

- A. $P(\text{pressure of an ideal gas}) = \frac{1}{2}\rho\langle c^2 \rangle$
- B. For a mixture of two gases in equilibrium in a container, $\frac{\rho_2}{\rho_1} = \sqrt{\frac{\langle c_1^2 \rangle}{\langle c_2^2 \rangle}}$
- C. For a mixture of two gases in equilibrium in a container, $\frac{\rho_2}{\rho_1} = \frac{\langle c_2^2 \rangle}{\langle c_1^2 \rangle}$
- D. ✓ **For a mixture of two different gases with equal partial pressure and equal number of molecules in a container, $\frac{m_2}{m_1} = \frac{\langle c_1^2 \rangle}{\langle c_2^2 \rangle}$.**

Answer: D

The pressure of an ideal gas is given by $P = \frac{1}{3}nm\langle c^2 \rangle$, where $n = N/V$. For equal pressures, volumes, and number of molecules, we have $m_1\langle c_1^2 \rangle = m_2\langle c_2^2 \rangle$, which yields $\frac{m_2}{m_1} = \frac{\langle c_1^2 \rangle}{\langle c_2^2 \rangle}$.

26. Which of the following statement is NOT correct?

(1)

- A. No process is possible in which there is an overall decrease in the entropy of the universe.
- B. The spontaneous transfer of energy from cooler body to a hotter body is not possible.
- C. ✓ **Spreading out of random kinetic energy through heating does not represent an overall increase in entropy.**
- D. The complete conversion of energy from a hot source into work is not possible.

Answer: C

Heating always increases the random kinetic energy of a system's particles, which corresponds to a greater number of microstates and therefore represents an overall increase in entropy, making statement C incorrect.

27. Which one of the following is not an example of simple harmonic motion? (1)
- A. A mass attached to a spring system oscillating in horizontal direction to the surface of the Earth
 - B. Oscillation of simple pendulum
 - C. ✓ **Rotation of second pointer in hand watch**
 - D. A mass attached to a spring system oscillating in vertical direction to the surface of the Earth

Answer: C

The second hand of a watch moves in uniform circular motion with constant speed, which is a periodic motion but not simple harmonic motion since it lacks a restoring force proportional to displacement towards an equilibrium point.

28. Travelling wave is given by the equation $Y = A \cos(kx - \omega t)$, where k is the wave number and ω is the angular frequency. What is the distance that the wave travels in the time $t = T/2$? (1)
- A. full wavelength
 - B. ✓ **half the wavelength**
 - C. a quarter of the wavelength
 - D. at the origin

Answer: B

A travelling wave travels a distance of one wavelength λ in one complete period T . In half of a period ($t = T/2$), the wave travels a distance equal to half the wavelength ($s = \lambda/2$).

29. A 50 cm pipe is open at one end and closed at the other end. When air is blow at 150 Hz. What is the velocity of the sound along the pipe? (1)
- A. 150 m/s
 - B. 100 m/s
 - C. 330 m/s
 - D. ✓ **300 m/s**

Answer: D

For a pipe open at one end and closed at the other, the fundamental frequency is $f_1 = \frac{v}{4L}$. Solving for the velocity $v = 4Lf_1 = 4 \times 0.5 \text{ m} \times 150 \text{ Hz} = 300 \text{ m/s}$.

30. In Young's double slit experiment, if the slit separation is 1.2mm and the average spacing of the bright fringes observed on a screen placed 4m away from the source is 2mm. What is the wavelength of the light source? (1)
- A. 550nm
 - B. ✓ **600nm**
 - C. 630nm
 - D. 750nm

Answer: B

Using the fringe spacing formula $w = \frac{\lambda D}{d}$, we can solve for the wavelength: $\lambda = \frac{wd}{D} = \frac{(2 \times 10^{-3} \text{ m}) \times (1.2 \times 10^{-3} \text{ m})}{4 \text{ m}} = 600 \text{ nm}$.

31. The colors seen from soap bubbles and oil slicks are a manifestation of thin film interference. What is the cause of this interference? (1)
- A. Interference from refraction of light
 - B. ✓ **Interference from reflection of light from the two surfaces of the film**
 - C. Interference from diffraction of light
 - D. Interference from superposition of lights that are incident and reflected

Answer: B

Thin film interference occurs when light waves reflecting off the outer surface of the film interfere with light waves reflecting off the inner surface of the film.

32. Two like charges of value q are fixed at $x = a$ and $x = -a$ as shown in the diagram below. (1)

If a test charge q_0 is released at $y = b$, which path will it follow?

[Figure: A coordinate system with the horizontal x -axis and vertical y -axis. Two equal charges of value q are positioned on the x -axis at coordinates $(-a, 0)$ and $(a, 0)$. A test charge labeled q_0 is located on the y -axis at $(0, b)$, with dashed lines connecting it to both charges at $(-a, 0)$ and $(a, 0)$.]

- A. It stays at $y = b$
B. along a line $y = -\frac{b}{a}x + b$
C. along a line $y = \frac{b}{a}x + b$
D. ✓ along y -axis

Answer: D

Due to the symmetrical placement of the two identical charges $+q$ on the x -axis, their horizontal components of electric force on any test charge on the y -axis cancel out, leaving a net force that acts entirely along the y -axis.

33. Two equal and opposite charges are located along x -axis at -2.0 cm and $+2.0$ cm as shown in the figure below. How much would be the electric potential at the origin? (1)

[Figure: A horizontal line showing two charges: a charge of $-4 \mu\text{C}$ located at -2 cm to the left of the origin (labeled O), and a charge of $+4 \mu\text{C}$ located at $+2$ cm to the right of the origin.]

- A. ✓ Zero
B. 1.8 MV
C. 3.6 MV
D. 4.5 MV

Answer: A

The electric potential at the origin is the algebraic sum of the potentials from each charge: $V = \frac{kq_1}{r} + \frac{kq_2}{r}$. Since $q_1 = -q_2 = -4 \mu\text{C}$ and both are at the same distance $r = 2$ cm, the potentials cancel out to yield exactly zero.

34. A sheet of polythene ($\epsilon_r = 2.3$) and 0.25 mm thick is to be used in a capacitor by sandwiching it between two sheets of aluminum foil. What area must the sheets have if the capacitor is to have a capacitance of $0.5 \mu\text{F}$? (1)

- A. 12 m^2
B. ✓ 6.14 m^2
C. 0.6 m^2
D. 0.12 m^2

Answer: B

Using the formula for capacitance of a parallel plate capacitor, $C = \frac{\epsilon_r \epsilon_0 A}{d}$, we can solve for the area: $A = \frac{Cd}{\epsilon_r \epsilon_0} = \frac{0.5 \times 10^{-6} \times 0.25 \times 10^{-3}}{2.3 \times 8.85 \times 10^{-12}} \approx 6.14 \text{ m}^2$.

35. A metal rod is measured to have a resistance R . If the same metal rod is stretched to reduce its radius by half without affecting its density, what is its new resistance? (1)

- A. $2R$
B. $4R$
C. $8R$
D. ✓ $16R$

Answer: D

Stretching a metal rod to half its radius reduces its cross-sectional area to $A/4$. To keep the volume constant, its length must increase to $4L$. Since $R = \rho \frac{L}{A}$, the new resistance becomes $16R$.

36. The statement of Kirchhoff's point rule follows from: (1)

- A. ✓ conservation of charge
B. conservation of energy
C. Ohm's law
D. dependence of resistance on temperature

Answer: A

Kirchhoff's point rule (or junction rule) states that the total current entering a junction equals the total current leaving it, which is a direct consequence of the conservation of electric charge.

37. You are given the bridge circuit as shown in the diagram below. The resistance R is used to limit the current in the galvanometer. Which of the following is correct in measuring R_x ? (1)

[Figure: A bridge circuit connected across a DC voltage source labeled V_{source} on the left. The bridge forms a diamond with four resistor arms: top-left has resistor R_1 , bottom-left has resistor R_2 , top-right has resistor R_3 , and bottom-right has resistor R_x . Across the horizontal diagonal between the left and right junctions is a galvanometer labeled 'G' connected in series with a resistor labeled 'R4'.]

- A. The bridge is balanced when $\frac{R_1}{R_2} = \frac{R_3}{R_4}$
 B. ✓ **The bridge balance condition is given by $\frac{R_x}{R_3} = \frac{R_2}{R_1}$.**
 C. $\frac{R_x}{R_3} = \frac{R_1}{R_4}$
 D. $\frac{R_x}{R_3} = \frac{R_2}{R_4}$

Answer: B

For a balanced Wheatstone bridge, the ratio of the resistances in the two branches must be equal, giving $\frac{R_1}{R_2} = \frac{R_3}{R_x}$. Rearranging this equation yields the balance condition $\frac{R_x}{R_3} = \frac{R_2}{R_1}$.

38. What is the expression of the centripetal acceleration of a particle of charge q and mass m moving in a uniform magnetic field B on a circle of radius r if $\vec{B}$ is perpendicular to the particle's direction of motion? (1)

- A. $\frac{qB}{m}$
 B. $\frac{2qB}{mr}$
 C. $\frac{q^2 B^2}{m} r$
 D. ✓ $\frac{q^2 B^2}{m^2} r$

Answer: D

The magnetic force provides the centripetal acceleration, so $qvB = ma_c$. Since the orbital radius is $r = \frac{mv}{qB}$, we substitute $v = \frac{qBr}{m}$ into the acceleration equation to get $a_c = \frac{qvB}{m} = \frac{q^2 B^2}{m^2} r$.

39. Two long wires of 10 m in length carries a current of 2.0 A and 0.5A in the same direction. The wires are separated by 4.0 cm. What is the magnetic force that the wires exerted on each other? (1)

- A. ✓ $5 \times 10^{-5} \text{ N}$
 B. $5 \times 10^{-6} \text{ N}$
 C. $5 \times 10^{-7} \text{ N}$
 D. $4 \times 10^{-6} \text{ N}$

Answer: A

The magnetic force between two parallel wires is $F = \frac{\mu_0 I_1 I_2 L}{2\pi d} = \frac{(4\pi \times 10^{-7}) \times 2.0 \times 0.5 \times 10}{2\pi \times 0.04} = 5 \times 10^{-5} \text{ N}$.

40. Lenz's law in electromagnetic induction follows from which law of conservation ? (1)

- A. charge
 B. ✓ **energy**
 C. momentum
 D. mass

Answer: B

Lenz's law states that the direction of an induced current always opposes the change in magnetic flux that produced it, which ensures that electrical energy is not created from nothing, complying with the conservation of energy.

41. A rectangular loop of area 0.4 m^2 is placed in a magnetic field that is changing at a rate of 100T/s. If the normal of the loop makes angle 60° with the magnetic field, what is the magnitude of induced emf? (1)

- A. 80V
 B. 40V
 C. ✓ **20V**
 D. 34.64V

Answer: C

The magnitude of the induced emf is given by Faraday's law: $|\varepsilon| = A \cos \theta \frac{dB}{dt} = 0.4 \text{ m}^2 \times \cos(60^\circ) \times 100 \text{ T/s} = 20 \text{ V}$.

42. The applied ac voltage and the resulting current, in a circuit element, is shown below (1)

What is the circuit element ?

[Figure: A Cartesian coordinate graph with a horizontal axis labeled 'Time' and a vertical axis marked with '+', '0', and '-'. Two sinusoidal waveforms are shown: a solid curve labeled 'Voltage' passing through the origin (0, 0) and going positive, and a dashed curve labeled 'Current' which is shifted to the right by a quarter period (90° phase lag behind the voltage wave), reaching its first positive peak a quarter cycle after the voltage waveform peaks.]

- A. ✓ inductor
B. capacitor
C. resistor
D. diode

Answer: A

In an inductor, the current lags behind the applied voltage by a phase angle of 90° (or a quarter period), which matches the graphical representation where the current waveform is shifted to the right of the voltage waveform.

43. A series circuit consisting of 50 Ω resistor and capacitor of capacitive reactance 50 Ω are connected to alternating source of voltage(rms) 100V. What is the average power output and power factor of the circuit? (1)

- A. 141.4W, 0.8
B. 200W, 0.8
C. 70.7W, 0.707
D. ✓ 100W, 0.707

Answer: D

The impedance is $Z = \sqrt{R^2 + X_C^2} = 50\sqrt{2} \Omega$. The power factor is $\cos \phi = R/Z = 1/\sqrt{2} \approx 0.707$, and the average power is $P = I^2 R = (\frac{V}{Z})^2 R = (\frac{100}{50\sqrt{2}})^2 \times 50 = 100 \text{ W}$.

44. When ultraviolet light is shone on a clean metal surface the surface will emit electrons. What is the necessary precondition for electrons to be ejected from the metal surface is ? (1)

- A. The intensity of light must be high enough
B. The minimum energy required to release the electron is the same as the work function of the metal
C. The wave length of the light has to be greater than that of ultraviolet light.
D. ✓ The frequency of the metal has to be less than that of ultraviolet light.

Answer: D

For photoelectric emission to occur, the frequency of the incident light must be greater than the threshold frequency of the metal, meaning the threshold frequency of the metal must be less than that of the incident ultraviolet light.

45. Complete the following equation which represents a nuclear fission reaction. What is the particle represented by X? $^{235}_{92}\text{U} + {}^1_0\text{n} \rightarrow {}^{95}_{37}\text{Rb} + {}^{139}_{55}\text{Cs} + 2\text{X} + \text{energy}$? (1)

- A. electron
B. proton
C. ✓ neutron
D. alpha particle

Answer: C

Balancing the mass numbers gives $235 + 1 = 95 + 139 + 2A_X \Rightarrow 2A_X = 2 \Rightarrow A_X = 1$. Balancing the atomic numbers gives $92 + 0 = 37 + 55 + 2Z_X \Rightarrow Z_X = 0$. Thus, X is a neutron (${}^1_0\text{n}$).

— END OF MARKING KEY —

Generated on Meskerem 22, 2019 E.C. (October 2, 2026 G.C.) · Temari.et