Contest 1

(1)	What is the work done by an ideal gas in a process in which its volume changes from $2.0\ \text{m}^3$ to $6.0\ \text{m}^3$ at a constant pressure of 200 kPa? **Ans: 800 kJ**
(2)	Find the resistance of a resistor which dissipates 200 W when the current through it is 5 A. **Ans: 8 Ω**
(3)	A 2 kg object moving at $5\ \text{m s}^{-1}$ collides head-on with and becomes attached to a stationary 1 kg object. Give the direction in which the objects move relative to the velocity of the incoming object. **Ans: They move in the same direction as the incoming object**

(1)	Find the internal energy of $10\ \text{mol}$ of a monatomic ideal gas at a temperature of $200\ \text{K}$. **Ans: 25 kJ**
(2)	Find the magnitude of the lateral magnification a convex mirror of focal length $-20\ \text{cm}$ produces of an axial object $20\ \text{cm}$ from its vertex. **Ans: 0.5**
(3)	The impedance of an ac circuit is $50\ \Omega$ at the frequency of a signal with a root-mean-square voltage of $20\ \text{V}$. Find the root-mean-square current in the circuit when the signal is applied across it. **Ans: 0.4 A**

(1)	The impedance of an ac circuit is $75\ \Omega$ at the frequency of a signal applied across the circuit. Find the rms voltage across the circuit if the rms current in it is 0.40 A. **Ans: 30 V**
(2)	A 2 kg object moving at $15\ \text{m s}^{-1}$ collides head-on with and becomes attached to a stationary 1 kg object. Find the common speed of the objects after the collision. **Ans: $10\ \text{m s}^{-1}$**
(3)	The bob of a simple pendulum which has a length of 2.0 m and a bob of mass 0.8 kg swings to an extreme position that is 0.25 m above its lowest position. Find the kinetic energy of the pendulum when it returns to its lowest position. **Ans: 2 J**

(1)	Determine the temperature at which the wavelength for maximum intensity in the spectrum of a blackbody is 1.00 μm. You may take the Wien constant as 2.90×10^{-3} K m and the Stefan-Boltzmann constant as 5.67×10^{-8} W m^{-2} K^{-4}. **Ans: 2900 K**
(2)	A 0.2 mC charged particle moves at 4 m s^{-1} in a uniform 5 T magnetic field. Find the magnitude of the force on the particle if the angle between the field and the velocity of the particle is 30°. **Ans: 2 mN**
(3)	Find the maximum horizontal range a projectile launched at 20 m s^{-1} from level ground can attain. **Ans: 40 m**

(1)	Two very large parallel plates separated by 4 mm have a potential difference of 800 V across them. Find the magnitude of the electric field between the plates. **Ans: 200 kV m^{-1}**
(2)	Water escapes from a small hole near the bottom of a large tank containing water to a depth of 1.8 m. Find the speed with which the water escapes from the hole. **Ans: 6 m s^{-1}**
(3)	A heat engine absorbs 750 J of heat at a hot reservoir and rejects 450 J of heat at a cold reservoir. What is the thermal efficiency of the engine? **Ans: 40** %

(1)	A 2 kg object collides head-on with and becomes attached to a stationary 1 kg object and the two objects take off at 6 m s^{-1} after the collision. Find the speed of the incoming object. **Ans: 9 m s^{-1}**
(2)	Determine the power developed when the point of application of the force given by $\boldsymbol{F} = (3\hat{\boldsymbol{\imath}} + 5\hat{\boldsymbol{\jmath}})$ N moves with velocity $\boldsymbol{v} = (-6\hat{\boldsymbol{\imath}} + 4\hat{\boldsymbol{\jmath}})$ m s^{-1}. **Ans: 2 W**
(3)	What is the magnitude of the impulse of a 16 N force that acts for 15 ms? **Ans: 0.24 N s**

(1)	An ideal gas initially at 200 K expands at constant pressure from a volume of 0.50 m^3 to a volume of 0.80 m^3. Find the final temperature of the gas. **Ans: 320 K**
(2)	A current of 2 A flows through a single-turn square loop of side 0.2 m in a uniform 5 T magnetic field that is parallel to the face of the loop. Find the magnitude of the magnetic torque on the loop. **Ans: 0.4 N m**
(3)	What is the greatest distance of an axial object from the vertex of a concave spherical mirror at which the image of the object is virtual? **Ans: Focal length or half the radius of curvature of the mirror**

(1)	Determine the temperature at which the mean speed for an ideal gas of molar mass 32×10^{-3} kg mol^{-1} is 250 m s^{-1}. **Ans: 94 K**
(2)	A particle of mass 0.05 kg oscillates at the end of a spring of spring constant 500 N m^{-1}. Find the magnitude of the acceleration of the particle when its displacement from equilibrium is 2 mm. **Ans: 20 m s^{-2}**
(3)	Find the magnetic force on a 5 C charge moving in a uniform magnetic field of flux density $(-2\hat{\boldsymbol{\imath}} + 3\hat{\boldsymbol{\jmath}})$ T at the instant its velocity is $(2\hat{\boldsymbol{\imath}} + 3\hat{\boldsymbol{\jmath}})$ m s^{-1}. **Ans: $60\hat{\boldsymbol{k}}$ N**

(1)	Find the kinetic energy of a particle moving in a circle of radius 4 m when the centripetal force on it is 100 N. **Ans: 200 J**
(2)	A 5 m long simple pendulum with a bob of mass 0.5 kg at rest at its equilibrium position is set in motion with an initial kinetic energy of 1 J. How high does the bob rise above its equilibrium point? **Ans: 0. 2 m**
(3)	The density of a substance is determined by measuring the mass and volume of a sample of the substance. If the relative error in the mass measurement is 1 % and the relative error in the volume measurement is 2 %, what is the relative error in the density result? **Ans: 3** %

(1)	Find the magnitude of the centripetal force on an object moving in a circle of radius 5 m when its kinetic energy is 400 J. **Ans: 160 N**
(2)	Determine the temperature at which the wavelength for maximum intensity in the spectrum of a blackbody is 0.500 μm. You may take the Stefan-Boltzmann constant as 5.67×10^{-8} W m^{-2} K^{-4} and the Wien constant as 2.90×10^{-3} K m. **Ans: 5800 K**
(3)	The magnitude of the gravitational field a distance R from the surface of a uniform sphere of radius R is g. Find the magnitude of the gravitational field a distance $2R$ from the surface. **Ans: $4g/9$**

(1)	The length of an object is measured repeatedly and the following results were obtained: 0.21 m, 0.22 m, 0.19 m, 0.21 m, and 0.22 m. What is the best experimental value of the length of the object? **Ans: 0.21 m**
(2)	What is the moment of inertia of a uniform sphere of radius 0.02 m and mass 0.2 kg about an axis passing through its center? **Ans: 3.2×10^{-5} kg m^2**
(3)	A capacitor network is made up of a 5 μF capacitor in series with a parallel connection of a 2 μF and a 3 μF capacitor. Find the time constant of the circuit obtained by connecting the capacitor network in series with a 10 Ω resistor. **Ans: 25 μs**

(1)	Fluid of density 960 kg m^{-3} escapes from a small hole near the bottom of a tank with a cross-sectional area much larger than the area of the hole. Find the speed with which the fluid escapes from the hole when the depth of fluid in the tank is 7.2 m. **Ans: 12 m s^{-1}**
(2)	A 16 kg object on a rough horizontal surface remains at rest when pulled by a 48 N force that makes an angle of 60° with the horizontal. What is the magnitude of the friction force on the object? **Ans: 24 N**
(3)	An object oscillates at the end of a spring of spring constant 500 N m^{-1}. Find mass of the object if the magnitude of its acceleration is 5 m s^{-2} when the magnitude of its displacement from equilibrium is 2 mm. **Ans: 0.2 kg**

(1)	The resonance frequency of an ideal LC circuit is 500 Hz when $L = 20$ mH. What is the resonance frequency of the circuit when L is changed to 80 mH? **Ans: 250 Hz**
(2)	A 2 kg object is lifted steadily at 1 m s^{-1} from the ground. What is the mechanical energy of the object when it is 2 m above ground? **Ans: 41 J**
(3)	The impedance of an RC circuit with $R = 112\ \Omega$ is $113\ \Omega$ at 2.5 kHz. Find C. **Ans: 4.2 μF**

(1)	A 2 kg object moving at 6 m s^{-1} collides head-on with and becomes attached to a stationary 1 kg object. Find the total kinetic energy of the objects after the collision. **Ans: 24 J**
(2)	A heat engine absorbs 700 J of heat at a hot reservoir and rejects 400 J of heat at a cold reservoir. How much work does the engine do and what is its thermal efficiency? **Ans: $W = 300$ J and $\eta = 43$ %**
(3)	State the condition under which angular momentum is conserved. **Ans: Net torque is zero**

(1)	A 0.2 kg particle of charge -5 μC moving at 20 m s^{-1} enters a uniform 400 kV m^{-1} electric field parallel to the velocity of the particle. Find the speed of the particle 10 s after entering the field. **Ans: 80 m s^{-1}**
(2)	The coefficient of linear expansion of aluminum is 2.4×10^{-5} K^{-1}. At what temperature does the volume of an aluminum block initially at 0 ℃ increase by 0.36 %? **Ans: 50** ℃
(3)	The horizontal range of a 0.40 kg projectile launched at $15°$ to the horizontal is 50 m. Find its launch kinetic energy. **Ans: 200 J**

(1)	Find the magnitude of the acceleration of the weights in an Atwood machine with a pulley of negligible friction and rotational inertia in which the weights have masses 15 kg and 5 kg. **Ans: $5\ \mathrm{m\ s^{-2}}$**
(2)	A vehicle travels 20 km due north in 0.5 h, stops for 1 h, then travels 20 km due east in 0.5 h. What is the average speed of the vehicle? **Ans: $20\ \mathrm{km/h}$**
(3)	The coefficient of linear expansion of aluminum is $2.4 \times 10^{-5}\ \mathrm{K^{-1}}$. What is the thermal strain in a 5.0 m long aluminum bar whose temperature changes from 20 ℃ to 55 ℃? **Ans: 8.4×10^{-4}**

(1)	A solenoid of radius 2.0 cm and length 0.25 m has 250 turns of wire. What is the magnitude of the magnetic flux density near the center of the solenoid when the current in the wire is 5.0 A? **Ans: 6.3 mT**
(2)	Displacement along a certain progressive wave is given by $y(x,t) = (5\text{ m})\sin[(40\pi\text{ m}^{-1})x - (15\pi\text{ s}^{-1})t]$. What is the wavelength of the wave? **Ans: 0.05 m**
(3)	What is the magnitude of the acceleration of the weights in an ideal Atwood machine in which the masses of the weights are 3 kg and 7 kg? **Ans: 4 m s^{-2}**

(1)	A 16 kg object on a smooth horizontal table is pulled by a falling 4 kg object attached to it by a light inextensible string that passes over a frictionless pulley on the edge of the table. Find the tension in the string. **Ans: 32 N**
(2)	Displacement along a certain progressive wave is given by $$y(x,t) = (20\text{ m})\sin[(18\pi\text{ m}^{-1})x - (32\pi\text{ s}^{-1})t]\,.$$ Find the frequency of the wave. **Ans: 16 Hz**
(3)	What is the focal length of a converging lens for which the distance between the focus and the image of an object is 4 cm when the distance between the focus and the object is 36 cm? **Ans: 12 cm**

(1)	A 0.4 kg object swings at the end of a 1 m long inextensible string. What is the tension in the string when the object is moving at 5 m s^{-1} and is at the highest point of its trajectory? **Ans: 6 N**
(2)	State the conditions for static equilibrium of an object. **Ans: Net force equals zero AND net torque equals zero**
(3)	An 80 N object on a rough horizontal surface is pulled by a 76 N force that makes 30° with the horizontal. What is the normal force on the object? **Ans: 42 N**

(1)	What is the bulk modulus of a liquid of volume $600\ \text{cm}^3$ which decreases by $0.5\ \text{cm}^3$ under a pressure increase of 5 MPa? **Ans: 6 GPa**
(2)	A vehicle travels 20 km due north in 0.5 h, stops for 1 h, then travels 20 km due east for 0.5 h followed by 20 km due south for 0.5 h. What is the average velocity of the vehicle? **Ans: 8 km h^{-1} due east**
(3)	The heat capacity at constant volume of a quantity of monatomic ideal gas is $540\ \text{J K}^{-1}$. Find the heat capacity at constant pressure of the gas. **Ans: 900 J K^{-1}**

(1)	Find the magnitude of the electric field produced by an infinite conducting plate which carries a surface charge density of $8.85 \times 10^{-9}\ \mathrm{C\ m^{-2}}$. **Ans: $\mathbf{500\ V\ m^{-1}}$**
(2)	The surface gravity on a spherical body of radius R is g. What is the magnitude of the gravitational field a distance $2R$ above the surface? **Ans: $\boldsymbol{g/9}$**
(3)	A 0.50 kg projectile is launched from level ground at 45° to the horizontal with an initial kinetic energy of 400 J. What is the horizontal range of the projectile? **Ans: 160 m**

(1)	A projectile is launched horizontally at $20\ \text{m s}^{-1}$ from the top of a $20\ \text{m}$ high vertical tower. How far from the foot of the tower does the projectile fall? **Ans: 40 m**
(2)	The charge density of an infinitely long conducting wire is $-5.6 \times 10^{-5}\ \text{C m}^{-1}$. How many excess electrons are there on a $0.2\ \text{m}$ length of the wire? **Ans: 7×10^{13}**
(3)	What is the moment of inertia of a solid sphere of mass M and radius R about an axis that is tangent to its surface? **Ans: $7MR^2/5$**

(1)	A solenoid of diameter D and length L has N turns of wire. What is the magnitude of the magnetic flux near the center of the solenoid when the current in the wire is I? **Ans: $\pi D^2 \mu_0 NI/4L$ where μ_0 is the permeability of free space**
(2)	Find the length of a simple pendulum whose period is 4.00 s at a point where $g = 9.81$ m s^{-2}. **Ans: 3.98 m**
(3)	The initial volume of a liquid is 800 cm^3. The volume of the liquid decreases by 0.4 cm^3 the pressure on it increases by 5 MPa. What is the compressibility of the liquid? **Ans: 1×10^{-10} Pa^{-1}**

(1)	Give the number of emission lines that can be observed for a gas of hydrogen atoms in which atoms are excited to the state with quantum number $n = 4$. **Ans: 6**
(2)	The capacitor in an RC circuit with a time constant of 5.0 s is charged by maintaining a constant potential difference across the circuit. If the initial charging current is 10 A, what is the charging current after 10 s? **Ans: 1.4 A**
(3)	How many molecules are there in an ideal gas whose pressure and volume at 300 K are 83.1 kPa and 0.15 m^3? **Ans: 3.0×10^{24}**

(1)	The decay constant of a radionuclide is $0.0125\ s^{-1}$. Find the activity of a sample of the radionuclide 160 s after its activity attains 100 Bq. **Ans: 13.5 Bq**
(2)	The magnitude of the magnetic flux density 1 m from a long straight current carrying wire is 2 nT. Find the magnitude of the magnetic flux density 0.5 m from the wire. **Ans: 4 nT**
(3)	Arrange in increasing order of emission wavelength: Argon ion laser, carbon dioxide laser, helium-neon laser, nitrogen laser. **Ans: Nitrogen, argon ion, helium-neon, carbon dioxide**

(1)	An LR circuit with a time constant of $400\ \mu s$ is shorted after a steady current has been established. Find the current in the shorted circuit $800\ \mu s$ after it attains 0.20 A. **Ans: 0.027 A**
(2)	A 50 N horizontal force pulls a 3 kg object attached to a 2 kg object by a light inextensible string. The two objects lie on a smooth horizontal surface. What is the tension in the string connecting the objects? **Ans: 20 N**
(3)	Estimate the inductance of a solenoid wound with 800 turns per meter whose volume is $1.2 \times 10^{-6}\ \mathrm{m}^3$. **Ans: 0.97 nH**

(1)	Give the ice point on the thermodynamic scale. **Ans: 273. 15 K**
(2)	Why is a steam burn more painful than a burn from boiling water at the same temperature? **Ans: Condensation of the steam injects additional energy into the burn**
(3)	Why does a bird perching on a live uninsulated high-tension cable not get electrocuted? **Ans: Insufficient potential difference across the feet of the bird to cause significant current flow through the bird**