Materials for Final Exam for Discipline Physics-1

<u>You must commit to memory the following information:</u>

1. R=8,31 J/(K·mole)
2. Temperature scales in Kelvins and Celcius: T(K)=273,15+T(°C)
3. 1 hr is 1 hour: 1 hr = 60 min = 3600s
4. 1 eV = $1.6\cdot10^{-19}$ J
5. You must remember the following decimal prefixes:

Prefix	Symbol	Multiple	Prefix	Symbol	Multiple	Prefix	Symbol	Multiple	Prefix	Symbol	Multiple
Exa†	E	10^{18}	Mega	M	10^{6}	Deci†	d	10^{-1}	Nano	n	10^{-9}
Peta†	P	10^{15}	Kilo	k	10^{3}	Centi	c	10^{-2}	Pico	p	10^{-12}
Tera	T	10^{12}	Hecto†	h	10^{2}	Milli	m	10^{-3}	Femto†	f	10^{-15}
Giga	G	10^{9}	Deka†	da	10^{1}	Micro	μ	10^{-6}	Atto†	a	10^{-18}

Thus:

i. 1 m= 100 cm
ii. 1m=10 dm (decimeters)
iii. 1 s = 1000 ms, etc.

Commit to memory the following table:

	Mass (kg)	Charge (C)
Neutron, n	1.675×10^{-27}	0
Proton, p	1.673×10^{-27}	1.602×10^{-19}
Electron, e^-	9.11×10^{-31}	-1.602×10^{-19}

1. Topics for questions

1.1 Topics for questions for Mechanics

1. Vectors of position and displacement. Vectors of average and instantaneous velocity. Vectors of average and instantaneous acceleration. Displacement at constant acceleration in rectilinear motion.
2. Projectile motion: the angle of elevation, range of flight, maximal height, time of flight. Circular uniform motion.
3. The concept of force. Net force. Three fundamental forces.
4. Newton's first law of motion. Reference frame. Newton's second law. Newton's third law. Action and reaction forces.
5. Weight and mass. Work, work done by a varying force. Work of a spring. Kinetic energy. Work-energy theorem.
6. Conservative and nonconcervative forces. Power. Potential energy. Conservation of mechanical energy.
7. Linear momentum. The law of linear momentum conservation. Impulse-momentum theorem.
8. Collisions. Perfectly elastic collisions. Perfectly inelastic collisions. Energy loss in perfectly inelastic collisions.
9. Rotation of rigid bodies. Angular position, displacement, speed, velocity. Linear and angular velocities of a point at rotation.
10. Tangetial acceleration. Centripetal, centrifugal acceleration. Total linear acceleration. Angular velocity as a vector.

11. Rotational kinetic energy of a rigid body. Moment of inertia. Parallel-axis theorem. Torque.
12. Angular momentum. Rotational analogue of Newton's second law. Net external torque. Angular momentum of a rotating rigid body.
13. Angular acceleration. The law of angular momentum conservation. Units and dimensions for linear and angular displacement, velocity, acceleration; force, torque; angular momentum, pressure.
14. Equations for rotational and linear motions. Fluids: pressure. Atmospheric pressure. Pascal's principle.
15. Archimedes' principle. Bernoulli equation. Torricelli's law.

1.2 Topics for questions for Molecular Physics and Thermodynamics

1. Main assumptions for the ideal gas model. Pressure of an ideal gas. Molecular interpretation of temperature.
2. Root mean square speed of molecules, mean, most probable molecules velocities. Internal energy of an ideal gas. Equation of state for an ideal gas:
    b. PV=NkT (N – number of molecules)
    c. P=nkT (here n – number density of molecules (n=N/V))
    d. PV=nRT (here n – number of moles)
3. Evaporation, heat of evaporation. Saturation vapor pressure. Evaporation vs. boiling. Boiling point.
4. Collisions of gas molecules. Collision cross section, mean collision time, mean free path.
5. Transport phenomena. The critical temperature, absolute humidity, relative humidity.
6. Van-der-Waals gas model. Heat capacity, specific heat capacity.
7. Energy transfer and specific heat capacity. Dependence of specific heat capacity on temperature, volume and pressure.
8. Latent heat, specific latent heat. Work and heat in thermodynamic process.
9. Two ways of energy transfer. The first law of thermodynamics and heat transmission (heat flow).
10. Ideal gas processes: isobaric, isochoric, isothermal, adiabatic.
11. Polytropic processes. Cyclic processes.
12. Heat engines. Thermal efficiency of a heat engine. Heat pumps or refrigerators. Coefficient of performance of a refrigerator.
13. The second law of thermodynamics in the Kelvin form. The second law of thermodynamics in the Clausius form. The Carno cycle. The efficiency of the Carno cycle. The Carno theorem.
14. Thermodynamic definition of entropy. The second law of thermodynamics in the modern form (through entropy). Microscopic and macroscopic states of a system.
15. Entropy on a microscopic scale. Entropy as a measure of disorder. Statistical definition of entropy.

1.3 Topics for questions for Electricity

1. Electrostatic properties of electric charges. The law of conservation of charge. Elementary charges.
2. Coulomb's law. Electric field properties. Electric field of a point charge.
3. Volume, surface, linear charge density of a uniformly charged object. Electric Field of a Uniformly Charged ring. Gauss law. Electric flux.
4. Electric potential energy, electric potential, electric potential properties. The work of an electric field when a charge is passing difference of potentials. Relations among units (charge, voltage, potential, energy, electric field).
5. Conductors and insulators. Capacitance. Parallel-plate capacitor. The formula for capacitance of a parallel-plate capacitor.
6. Parallel combination of capacitors. Series combination of capacitors. Complex combination of capacitors.
7. Energy Stored in a Charged Capacitor. Three formulas for energy in a capacitor.
8. Dielectrics. Dielectric strength.Properties of dielectrics: polarization, polar and nonpolar types of dielectrics.
9. Capacitor with dielectric. Usage of dielectrics in capacitors.
10. Electric current. Direction of electric current. Ohm's law. Electromotive force.

11. Battery, internal resistance. Direct and alternating current.
12. Definition of the resistor. Parallel combination of resistors. Series combination of resistors. Complex combination of resistors.
13. Kirchoff's rules: loop rule, junction rule. Types of conductivity: conductors, semiconductors, insulators. Drift speed of electrons.
14. Current in metals.
15. Resistivity, resistance, conductivity. Ohm's law in the differential form ($J = \sigma E$). Dependence of resistance on temperature. Units for
    a. Charge
    b. Electric field
    c. Volume, surface, linear charge density
    d. Electric field flux
    e. Electric current
    f. Charge, passing difference of potentials.
    g. Capacitance

1.4 Topics for questions for Magnetism

1. Magnetic force of a magnetic field on a current. Magnetic force of a magnetic field on an arbitrary shaped wire with current. Curved wire in a uniform magnetic field.
2. Direction and magnitude of the force acting on a straight wire with current in a uniform magnetic field. Loop wire in a uniform magnetic field. Current loop torque in a uniform magnetic field.
3. Magnetic moment. Direction of magnetic moment of current loop. Potential Energy of a Magnetic Moment.
4. Motion of a charged particle in a uniform magnetic field. Lorentz force.
5. The Hall effect, hall voltage, hall constant. Usage of the Hall effect for magnetic field measuring. Usage of the Hall effect for determination of free charge carriers.
6. The Biot-Savart law. Magnetic field of a thin straight wire.
7. Magnetic field of an infinitely long straight wire. Magnetic force between two parallel conductors.
8. Ampere's law. Magnetic field of a solenoid. Magnetic flux.
9. The Gauss law in magnetism: magnetic flux through an enclosed surface. Displacement current. General form of the Ampere's law.
10. Faraday's law of induction. Lentz law. Emf, induced in a loop, and direction of the induced current by the changing magnetic flux. General form of Faraday's law of induction.
11. Eddy currents. Maxwell's equations. Properties of Maxwell's equations.
12. The phenomena of self-inductance. Self-induced emf. Inductance of an ideal solenoid. Series RL-circuit.
13. Energy in an inductor. Energy density of a magnetic field. Mutual Inductance.
14. LC Circuit Oscillations. RLC circuit.
15. Damping harmonic oscillations in RLC-circuit, critical resistance R_C. Damping inharmonic oscillations in RLC-circuit, critical resistance R_C.

2. Typical Problems

There will be problems like those below. Every examination card contains 2 random problems.

2.1 Problems for Mechanics

1. An object starts from 30 m/s velocity and reaches 126 km/h in a 1 km distance. Assuming a constant acceleration, what was the elapsed time?

2.The distance an ant moves in a straight-line motion is given by $x = 0.01t^3 - 0.05t^2 + 1.5t$ centimeters, where t is in seconds.

(a)Calculate the velocity for t = 5 s.

(b)What is the average velocity for the time interval from 1 to 2 min?

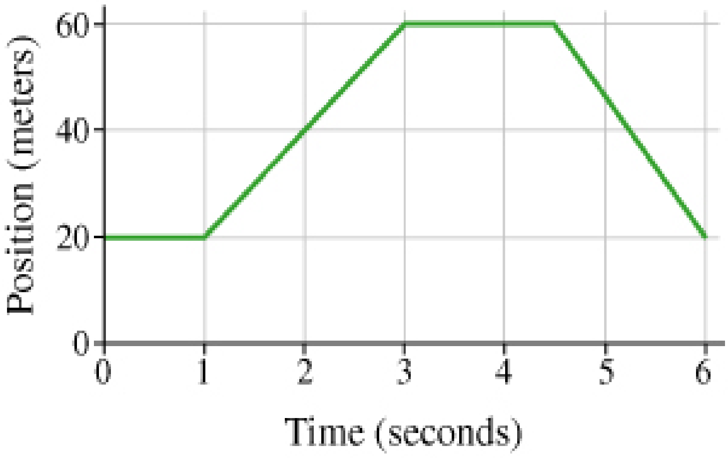
(c)Calculate the acceleration for t = 2 s.
(d)What is the average acceleration for the time interval from 1 to 2 min?
(e)Is the formula realistic for long times? Why?

3.Calculate the instantaneous velocity at:

1. t= 0.5 s
2. t = 2 s

Calculate the average velocity for time intervals:

3. from 0 to 2 seconds
4. from 1 to 6 seconds



4. Initial conditions: at t=0 S_0=0.
Calculate the position of the object at

1. t = 2 s

Calculate the distance travelled by an object for time interval:

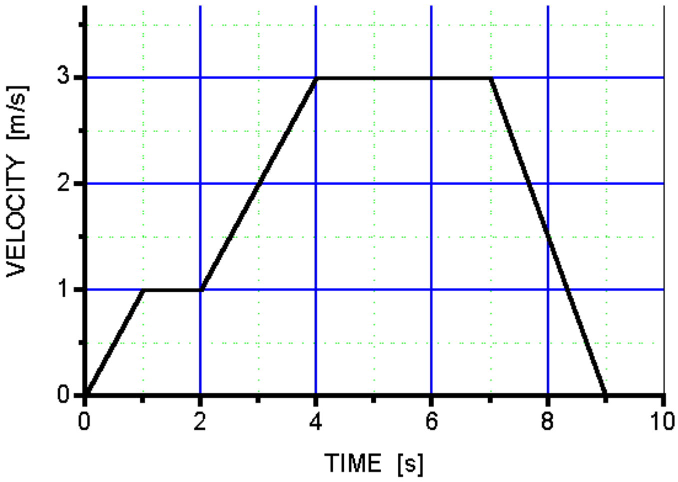
2. from 2 to 6 seconds

Calculate the average speed for time interval:

3. from 4 to 10 seconds

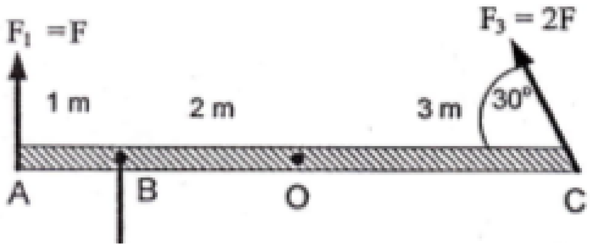
Calculate the instantaneous acceleration at:

4. t = 2 s



5. A forensic expert wants to examine the striations on a bullet fired by a gun. A bullet of mass 2.0 g is fired from the gun with muzzle speed 1000 mi/h into a special resistive material. The bullet is stopped in a distance of 1.4 dm. If we assume the negative acceleration is constant, what is the acceleration of the bullet inside the material and what force is exerted on the bullet as it accelerates?
6. A spring gun is made by compressing a spring (assumed to be perfect) and latching it. A spring of constant k = 60 N/ m is used and the latch is located at a distance of 7 cm from equilibrium. The pellets have mass 4 g. What is the muzzle velocity of the gun?
7. A nonstandard spring exerts a force $F = -k_1x - k_2x^3$ to restore itself to equilibrium, where x is the distance from equilibrium. The values of k_1 and k_2 are 5.0 N/m and 15 N/m^3 , respectively. Calculate the work done to stretch the spring from 0.10 to 0.20 m.
8. A wheel 30 cm in radius rotates at constant 5 rad/s^2. What is the magnitude of thelinear acceleration of a point located at (a) 10 cm from the center (b) 20 cm from the center (c) on the edge of the wheel?
9. A pulley 50 cm in radius. If the linear acceleration of a point located on the edge of the pulley is 2 m/s^2, determine the angular acceleration of the pulley.
10. A wheel 20 cm in radius is accelerated for 2 seconds from 20 rad/s to rest. Determine the magnitude of linear acceleration (a) a point located at 10 cm from the center (b) a point located at 10 cm from the center.
11. When you switch your room fan from medium to high speed, the blades accelerate at 1.2 radians per second squared for 1.5 seconds. If the initial angular speed of the fan blades is 3.0 radians per second, what is the final angular speed of the fan blades in radians per second?

12. The radius of a car tire is about 0.35 meters. If the car accelerates in a straight line from rest at 2.8 meters per second squared, what is the angular acceleration, both magnitude and direction, of the front passenger-side tire?
13. A merry-go-round has an angular acceleration of 0.30 radians per second squared. After accelerating from rest for 2.8 seconds, through what angle in radians does the merry-go-round rotate?
14. Three forces act on a beam with a length of 6 meters, as shown in the figure below. What is the net torque rotates the beam about the point as the axis of rotation?



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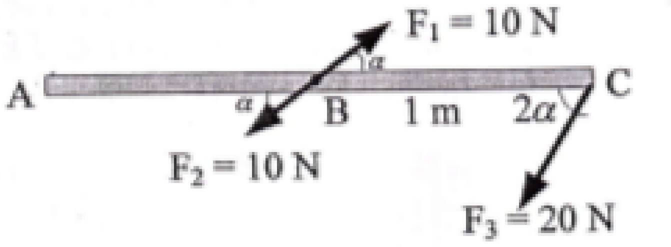
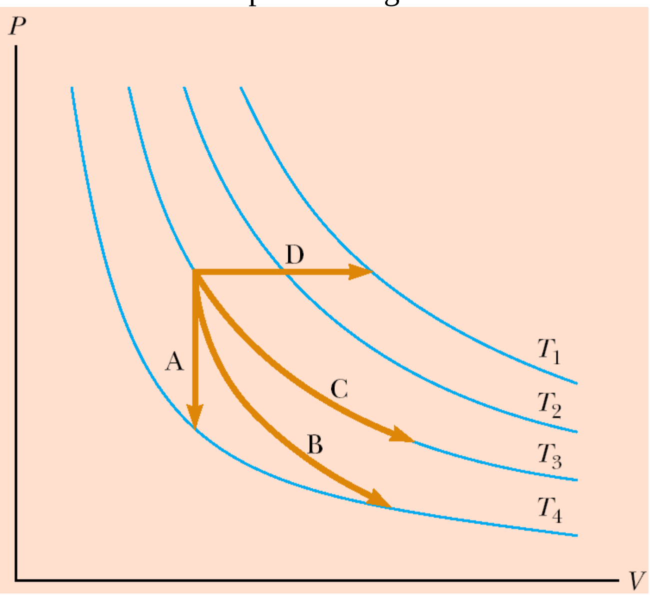
15. α = 30°, length of AB = BC = 1 meter. What is the moment of force about the axis of rotation at point A? *The axis of rotation at point A.*



2.2 Problems for Molecular Physics and Thermodynamics

1. Characterize the paths in Figure below as isobaric, isochoric, isothermal, or adiabatic.

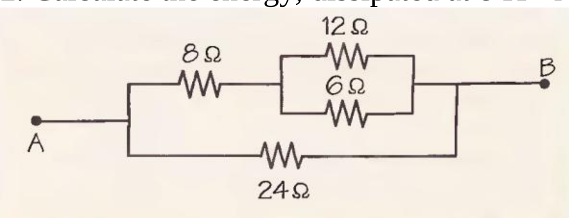


2. Calculate the amount of heat added to 1 gram gold to change phase from solid to liquid. The heat of fusion for gold is 64.5 x 10^3 J/kg.
3. Calculate the amount of heat released by 1 gram mercury to change phase from liquid to solid. Heat of fusion for mercury is 11.8 x 10^3 J/kg.
4. Determine the amount of heat absorbed by 1 kg water to change phase from liquid to vapor (steam). Heat of vaporization for water = 2256 x 10^3 J/kg
5. Determine the amount of heat released by nitrogen to change phase from vapor to liquid. Heat of vaporization for nitrogen = 200 x 10^3 J/kg
6. 3000 J of heat is added to a system and 2500 J of work is done by the system. What is the change in internal energy of the system?
7. 2000 J of heat is added to a system and 2500 J of work is done on the system. What is the change in internal energy of the system?
8. How much heat is needed to raise the temperature of a block of copper (weighing 0.5 kg) from 0°C to 100° C ? (for copper, c = 386 J/kg ^{o}C)

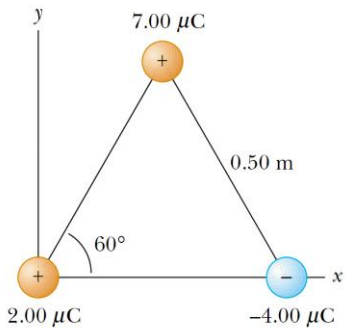
9. What would be the final temperature of a mixture of 100 g of water at 90°C and 600 g of water at 20°C ?
10. How much heat must be absorbed by 375 grams of water to raise its temperature by 25° C?
11. What mass of water can be heated from 25.0° C to 50.0° C by the addition of 2825 J?
12. What is the final temperature when 625 grams of water at 75.0° C loses 7.96 x 104 J?
13. A copper cylinder has a mass of 76.8 g and a specific heat of 0.092 cal/g·C. It is heated to 86.5° C and then put in 68.7 g of turpentine whose temperature is 19.5° C. The final temperature of the mixture is 31.9° C. What is the specific heat of the turpentine?
14. A 65.0 g piece of iron at 525° C is put into 635 grams of water at 15.0° C. What is the final temperature of the water and the iron?
15. Suppose 0.1 kg ice at 0°C (273K) is in 0.5kg water at 20°C. L_f =3.33x105J/kg
16. Suppose 0.1 kg ice at 0°C (273K) is in 0.5kg water at 20°C. What is the change in entropy of the ice as it melts at 0°C? Convert all temperatures into Kelvin!
17. Suppose 0.1 kg ice at 0°C (273K) is in 0.5kg water at 20°C. What is the change in entropy of the ice water as it warms up to the final temperature?
18. Suppose 0.1 kg ice at 0°C (273K) is in 0.5kg water at 20°C (293K). What is the change in entropy of the water as it melted the ice?
19. Carnot engine that operates between the temperatures T_H = 850K and T_L = 300 K, The engine performs 1200 J of work each cycle
    (a) what is the efficiency of this engine?
    (b) How much heat is extracted from the high-T reservoir each cycle?
    (c) How much heat is expelled into the low-T reservoir each cycle?
20. The van der Waals constants for xenon are a = 4.19 $(L^2\cdot atm)/mol^2$ and b = 0.0510 L/mol. If a 0.250 mol sample of xenon in a container with a volume of 3.65 L is cooled to −90°C, what is the pressure of the sample assuming ideal gas behavior? What would be the *actual* pressure under these conditions?
21. The van der Waals constants for water vapor are a = 5.46 $(L^2\cdot atm)/mol^2$ and b = 0.0305 L/mol. If a 20.0 g sample of water in a container with a volume of 5.0 L is heated to 120°C, what is the pressure of the sample assuming ideal gas behavior? What would be the *actual* pressure under these conditions?

2.3 Problems for Electricity

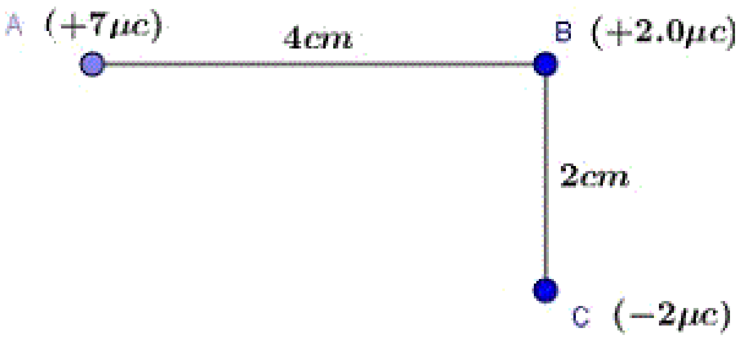
1. Two capacitors when connected in parallel give an equivalent capacitance of Cp and an equivalent capacitance of Cs when connected in series. What is the capacitance of each capacitor?
2. Calculate the energy, dissipated at 8 Ω - resistor during 36 hr. V_{AB} = 128 V.



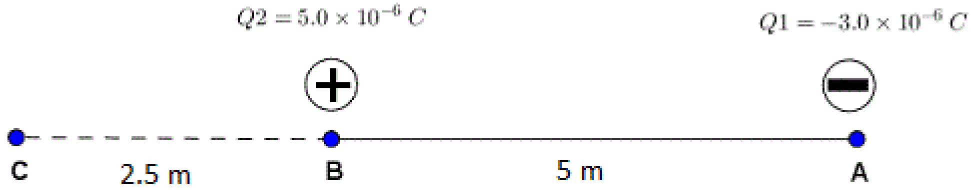
3. Three point charges are located at the corners of an equilateral triangle as shown in Figure below. Calculate the resultant electric force on the 7.00 μC charge.



4. What is the net force and its direction that the charges at the vertices A and C of the right triangle ABC exert on the charge in vertex B?



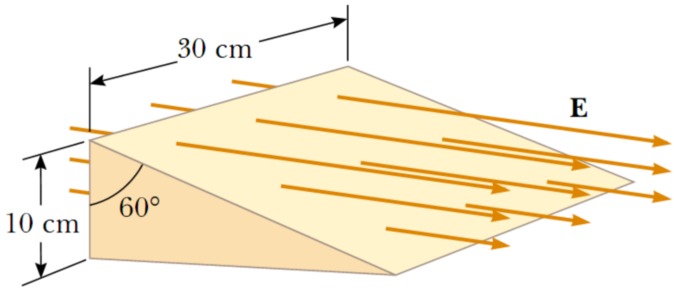
5. A positive charge q exerts a force of magnitude - 0.20 N on another charge - 2q. Find the magnitude of each charge if the distance separating them is equal to 50 cm.
6. Two identical objects, separated by a distance d, with charges equal in magnitude but of opposite signs exert a force of attraction of - 2.5 N on each other. What force do these objects exert on each other if the distance between them becomes 2d?
7. A charge of $q = -4.0 \times 10^{-6}$ is placed in an electric field and experiences a force of 5.5 N [E]
   a) What is the magnitude and direction of the electric field at the point where charge q is located?
   b) If charge q is removed, what is the magnitude and direction of the force exerted on a charge of -2q at the same location as charge q?
8. The distance AB between charges Q1 and Q2 shown below is 5.0 m. How much work must be done to move charge Q2 to a new location at point C so that the distance BC = 2.5 m?



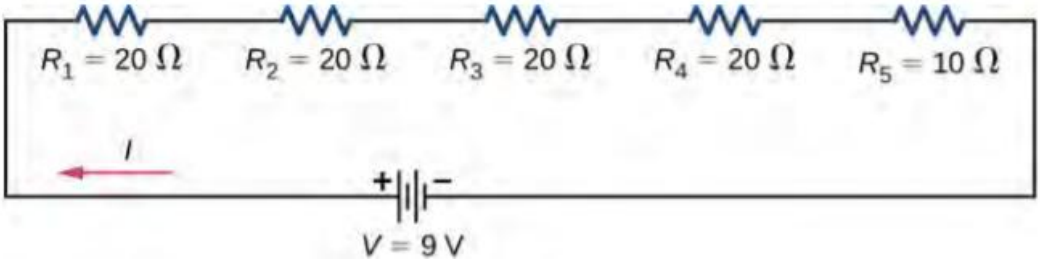
9. There are three charges q1, q2, and q3 having charge 6 C, 5 C and 3 C enclosed in a surface. Find the total flux enclosed by the surface.
10. Two point charges are separated by a distance of 10 cm. Charge on point A =+9 µCand charge on point B = -4 µC. $k = 9 \times 10^9\ Nm^2C^{-2}$, $1\ \mu C = 10^{-6}$ C. What is the change in electric potential energy of charge on point B if accelerated to point A ?

11. Consider a closed triangular box resting within a horizontal electric field of magnitude $E = 7.80 \times 10^4$ N/C as shown in Figure Below. Calculate the electric flux through

(a) the vertical rectangular surface,
(b) the slanted surface, and
(c) the entire surface of the box.



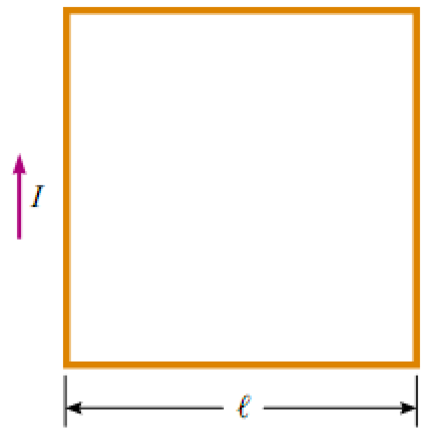
12. Equivalent Resistance, Current, and Power in a Series Circuit A battery with a terminal voltage of 9 V is connected to a circuit consisting of four 20-Ω and one 10-Ω resistors all in series (Figure). Assume the battery has negligible internal resistance. (a) Calculate the equivalent resistance of the circuit. (b) Calculate the current through each resistor. (c) Calculate the potential drop across each resistor. (d) Determine the total power dissipated by the resistors and the power supplied by the battery.



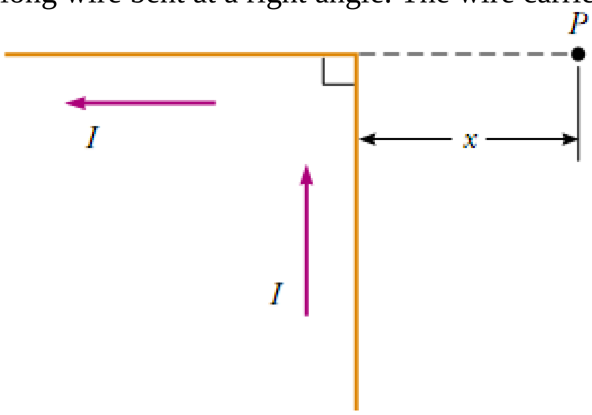
13. Analysis of a Parallel Circuit Three resistors R1 = 1.00 Ω, R2 = 2.00 Ω, and R3 = 2.00 Ω, are connected in parallel. The parallel connection is attached to a V = 3.00 V voltage source. (a) What is the equivalent resistance? (b) Find the current supplied by the source to the parallel circuit. (c) Calculate the currents in each resistor and show that these add together to equal the current output of the source. (d) Calculate the power dissipated by each resistor. (e) Find the power output of the source and show that it equals the total power dissipated by the resistors.
14. Analyzing a Circuit with a Battery and a Load A given battery has a 12.00-V emf and an internal resistance of 0.100 Ω. (a) Calculate its terminal voltage when connected to a 10.00-Ω load. (b) What is the terminal voltage when connected to a 0.500-Ω load? (c) What power does the 0.500-Ω load dissipate? (d) If the internal resistance grows to 0.500 Ω, find the current, terminal voltage, and power dissipated by a 0.500-Ω load.

2.4 Problems for Magnetism

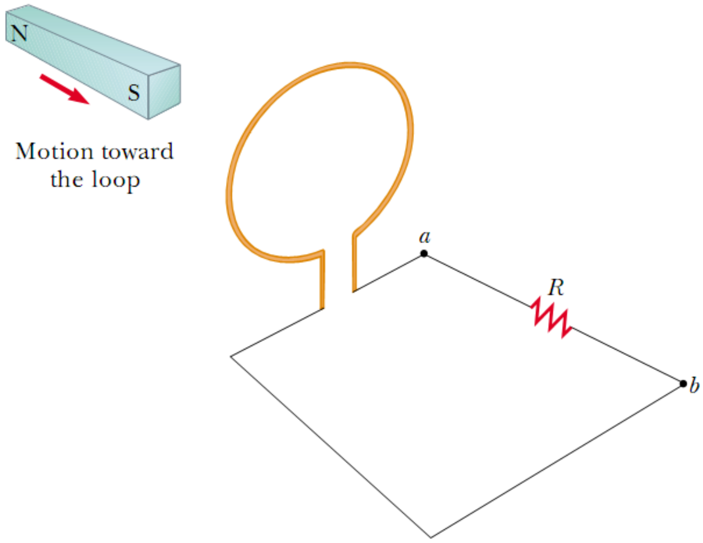
1. (a) A cosmic ray proton moving toward the Earth at 5.00×10^{7}m/s experiences a magnetic force of 1.70×10^{-16}N. What is the strength of the magnetic field if there is a 45º angle between it and the proton's velocity? (b) Is the value obtained in part (a) consistent with the known strength of the Earth's magnetic field on its surface? Discuss.
2. (a) A physicist performing a sensitive measurement wants to limit the magnetic force on a moving charge in her equipment to less than 1.00×10^{-12}N. What is the greatest the charge can be if it moves at a maximum speed of 30.0 m/s in the Earth's field? (b) Discuss whether it would be difficult to limit the charge to less than the value found in (a) by comparing it with typical static electricity and noting that static is often absent.
3. What is the field inside a 2 m-long solenoid that has 2000 loops and carries a 1600 A-current?
4. Find the current in a long straight wire that would produce a magnetic field twice the strength of the Earth's at a distance of 5 cm from the wire.
5. A circular current loop of radius 2 cm carries a current of 2 mA (a) What is the magnitude of its magnetic dipole moment? (b) If the dipole is oriented at 30 degrees to a uniform magnetic field of magnitude 0.5 T, what is the magnitude of the torque it experiences?
6. (a) A conductor in the shape of a square loop of edge length l= 0.4 m carries a current I=10 A as in Fig. Below. Calculate the magnitude and direction of the magnetic field at the center of the square.
(b) If this conductor is formed into a single circular turn and carries the same current, what is the value of the magnetic field at the center?



7. Determine the magnetic field at a point P located at a distance x from the corner of an infinitely long wire bent at a right angle. The wire carries a steady current I.



8. The bar magnet is moved toward the loop. Is V_a - V_b positive, negative, or zero?



9. A wire loop is bent into the shape of a square with each side of length 4.5 cm. The loop is placed horizontally on a tabletop with two of the sides oriented north/south and two of the sides oriented east/west. A battery is connected so that a current of 24 mA is produced around the loop; the current flows in the clockwise direction looking from the top. What is the force produced by the earth's magnetic field on each section of current-carrying wire? What is the overall torque on the loop? What would the torque be if the same length of wire were bent into a circle instead of a square (assuming the same current)?
10. A cyclotron is used to accelerate protons to a velocity of 35,000 m/s. If the magnetic field for the cyclotron is 0.75 Tesla, how large does the cyclotron have to be? If the protons are directed from the cyclotron to a velocity selector with the same magnetic field, what electric field is needed for the protons to pass through the selector?

11. A proton is moving at 12% of the speed of light in the direction which is 20 degrees up from west. It passes through the earth's magnetic field which points due north with a strength of 0.5 x 10-4 T. What is the resultant force on the proton? What will the radius of curvature of its path be?
12. A conductor in the shape of a square loop of edge length $\ell = 0.400$ m carries a current I = 10.0 A as in the figure. Calculate the magnitude and direction of the magnetic field at the center of the square.