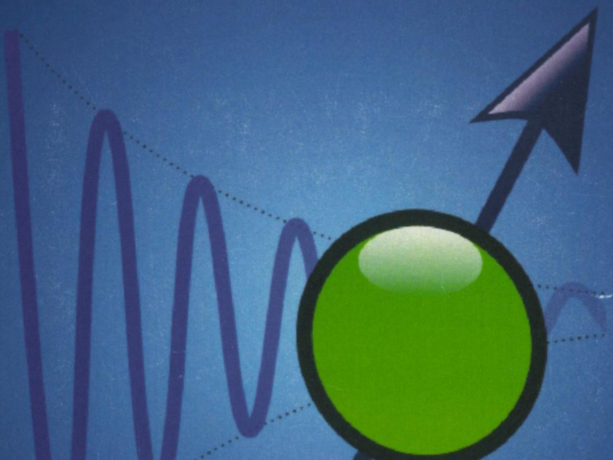
KAZAKH BRITISH TECHNICAL UNIVERSITY

V.V. Voronkov, F.F. Umarov

PROBLEMS FOR THE COURSE OF CLASSICAL PHYSICS (PHYSICS I)



Алматы 2012

Ministry of Education and Science of Republic of Kazakhstan

Kazakh-British Technical University

Faculty of Oil and Gas Industry

Engineering-Physics Department

V.V. Voronkov, F.F. Umarov

PROBLEMS FOR THE COURSE OF CLASSICAL PHYSICS (PHYSICS I)

Almaty

Problems for the Course of Classical Physics (Physics I). Teaching Aid. – Almaty: Kazakh-British Technical University, 2012. 93 pp., 58 figirues, 5 tables.

This teaching aid is based on literature sources and includes problems and questions for the course of Classical Physics (Physics I). The subject matter and contents of lectures correspond to the syllabus on Physics developed by the authors for 2011—2012 academic year, and this syllabus is presented at the end of this book. The content of the manual follows the structure of the syllabus and consists of 4 modules: Mechanics, Molecular Physics and Thermodynamics, Electricity and Magnetism. Each module contains questions, problems and Individual Home Works (IHW) variants in the form of tables. Book includes tables for main physical quantities and constants. This material is helpful for university students of technical specialities for studying Physics in English as an additional source of information and reference.

Reviewers:

Associated Professor of the Physical Engineering Department of the KBTU Doctor of Pedagogical Sciences, Professor Musabekov O.U.

Professor of the Department of Theoretical and Experimental Physics of the National Pedagogical University after Abai, Doctor of Sciences in Physics and Mathematics, Professor Mukashev K.M.

Approved on the Meeting of the Educational-Methodological Council of the Kazakh-British Technical University, Protocol N , 2012.

Preface

Physics can be defined as the science that investigates the fundamental concepts of matter, energy, space and the relationships among them. This tutorial is designed for a first-year university calculus-based physics course and included Problems and Individual Home Works for Classical Physics. Solution of physics problems is an essential basis for studying physics course and reliable instrument for control of a student's degree of understanding of physics laws. It also encourages students to develop independent creative style of thinking, teaches them to analyze observed phenomena, to distinguish the main factors and neglect insignificant ones. That is why solution of problems of physics resembles the approach of scientific physics research. Meanwhile solution of problems demands not only knowledge of laws of physics but serious methodical approach as well. While designing this tutorial the materials listed in [1-4] were used.

Individual Home Works (IHW) to Discipline "Classical Physics" ("Physics I")

Perfection in quality of education and effectiveness of teaching and studying of academic disciplines depends significantly on the level of organization and quality of individual work of students which is emphasized in organization of studying process in the conditions of the credit technology. Individual work of students is the basis of preparation of modern specialists who can quickly and successfully adapt to difficult conditions and make correct decisions in any situations, even the most unexpected ones. The effectiveness of independent work of students depends on many constituents: implementation of modern educational technologies, supplies of educational, methodological and scientific literature, reference books, sufficiency of workplaces equipped with modern electronic technology with the Internet access, and the level of organization of office-hours of instructors.

The skill of solving problems is the best parameter of estimation of mastering of the training course. Developing of such ability depends on the types of problems which a student can individually solve during the time given by the curriculum. This manual gives Individual Home Works (IHW) to the basic discipline

"Classical Physics" ("Physics I") which are physics problems and questions in accordance with the lecture material. These tasks are given to students for solution during the semester. The number of IHW given to students during the semester, the schedule of defense and their estimation are given in the syllabus of the discipline in the end of the manual.

Directions to Individual Home Works

The number of variants and topics will be chosen by the instructor.

It is recommended to start performing the IHW after studying of corresponding material, careful learning of exemplary solutions of typical problems given in methodical directions to corresponding sections.

IHW must be performed in an ordinary notebook where the following information of the student must be written on the cover: the surname and name, year, group, specialty, faculty, Individual Home Works to "Classical Physics" ("Physics I");

Pages of the notebook must contain margins for instructor's notes. Every problem must be started from a new page. The statement of a problem is to be written completely without shortenings. The solution of the problem must contain the main laws and formulae which are the basis of the problem, wording formulations of these laws, explanation of the symbols used in the formulae. If a specific formula which is valid only for a specific case and does not express any fundamental physical law is used in a solution then this formula must be derived from corresponding fundamental laws.

Whenever it is possible, a solution must contain a picture explaining the problem. A solution must be accompanied by brief but comprehensive written explanations.

The result must be obtained in the general form (i.e. in parameters and quantities), the dimensions of the final formula must be checked, and then the final number must be calculated with corresponding units.

All magnitudes of the statement of the problem must be written in units of one system (preferably SI) and given in a column for clearness.

1. Mechanics
1.1 Kinematics

Questions

1. What is the difference between Mechanics and Kinematics?
2. Does the absolute value of the displacement vector equal the length of the trajectory of a particle?
3. What is the difference between average and instantaneous acceleration?
4. What is the difference between speed and velocity?
5. What is changing in a uniform circular motion:
- angular speed,
- absolute value of linear speed,
- vector of linear speed,
- direction of linear speed,
- absolute value of tangential acceleration,
- vector of tangential acceleration,
- direction of tangential acceleration,
- absolute value of centripetal acceleration,
- vector of centripetal acceleration,
- direction of centripetal acceleration?
6. Make examples of motion with zero tangential acceleration.
7. Make examples of motion with zero centripetal acceleration.
8. Does the parabolic motion of projectiles apply to a missile traveling from a launch pad to a target area 5000 mi downrange?
9. What is the difference between units and dimensions?
10. Give some examples of motion in which the speed is constant but the velocity is not.
11. In the absence of air resistance, the same time is required for a projectile to reach its highest point as is required for it to return. Will this be true if air resistance is not neglected? Explain.
12. At what angle should a baseball be thrown to achieve its maximum range? At what angle must it be thrown to attain the maximum height?
13. Is the motion of a projectile fired at an angle an example of uniform acceleration? What is it if it is fired vertically upward or vertically downward? Explain.

Problems

Relative motion

1. A sailor wants to travel due east from Miami at a velocity of 15 km/h with respect to a coordinate system fixed on land. The sailor must contend with the Gulf Stream. which moves north at 5 km/h. With what velocity with respect to the water should the sailboat proceed under sail?
(Answer: 15.8 km/h, 18° south of east.)

2. Rain is falling steadily but there is no wind. You are in an automobile that moves at 80 km/h, and you see from the drops on a side window that the rain makes streaks at a 58° angle with respect to the vertical. What is the vertical velocity of the raindrops?
(Answer:50 km/h.)

Motion with constant velocity

3. An automobile driver travels north for 2 min at 30 mi/h, then stops at a red light for 30 s before proceeding again for 3 min at 45 mi/h. He then stops at a stop sign for 3 s, drives forward at 30 mi/h for 2 min, and finally stops for gas.
(a) How far does the automobile travel?
(b) What is the average velocity? Use units of miles and minutes.
(Answer: (a) 4.3 mi; (b) 0.56 mi/min)

Motion with constant (uniform) acceleration

4. An automobile is able to accelerate at a constant value of 0.4 m/s^2. How long does it take the automobile to get to 35 km/h?
(Answer: 39 s)

5. A car traveling 25 mi/h must reach a minimum of 50 mi/h within a 1000-ft access lane. What must the car's constant acceleration be? (Answer: 2.02 ft/s^2)

6. An automobile starting from rest at t = 0 s undergoes constant acceleration on a straight line. It is observed to pass two marks separated by 64 m, the first at t = 8 s and the second at t = 12 s. What is the value of the acceleration?
(Answer: 1.6 m/s^2)

7. A car travels a distance of 86km at an average speed of 8m/s. How many hours were required for the trip?
(Answer: 2.99h).

8. A small rocket leaves its pad and travels a distance of 40m vertically upward before returning to the earth 5 s after it was launched. What was the average velocity for the trip?
(Answer: 16m/s).

9. An arrow accelerates from zero to 40m/s in the 0.5s it is in contact with the bow string. What is the average acceleration?
(Answer: 80m/s^2).

10. In a braking test, a car traveling at 60km/h is stopped in a time of 3s. What were the acceleration and stopping distance?
(Answer: 5.56m/s^2, 25.0m).

11. A rock is dropped from rest. When will its displacement be 18m below the point of release? What is its velocity at that time?
(Answer: 1.92s, 18.8m/s).

Freely Falling Bodies

12. A lead weight falls from a height of 6 m onto a muddy surface. It comes to rest after penetrating 0.4 cm into the surface. What was the magnitude of the average acceleration during the impact? How long did it take to stop? (Answer: 10^4 m/s^2, $7\cdot10^{-4}$ s).

13. A baseball leaves the bat with a velocity of 30m/s at an angle 30^0. What are the horizontal and vertical components of its velocity after 3s?
(Answer: 26.0m/s, 14.4m/s).

Motion with nonuniform acceleration

14. 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 velocities for t values of 1, 5, and 10 s.
(b)What is the average velocity for the first 10 s?
(c)Is the formula realistic for long times?
(Answer: (a) 1.4 cm/s; 1.8 cm/s; 3.5 cm/s; (b) 2.0 cm/s)

15. In a braking test, a car traveling at 60km/h is stopped in a time of 3s. What were the acceleration and stopping distance?
(Answer: $-5.56 m/s^2$;25.0m).

Projectile motion

16. A runner attempting a broad jump leaves the ground with a horizontal velocity of magnitude 9 m/s. Assuming the horizontal component of velocity is unaffected, what vertical component of velocity must the runner acquire to jump 9.5 m?
(Answer: 5.2 m/s)

17. A projectile is shot at an angle of 34° to the horizontal with an initial speed of 225 m/s. What is the speed at the maximum height of the trajectory?
(Answer: 187 m/s)

18. An athlete can jump vertically a distance of 40 in starting from a standing position.
(a) Find the speed with which the athlete left the ground.
(b) Assuming that he can leave the ground with the same starting speed as in part (a), find the jump height when the athlete jumps at a

45^0 angle. What horizontal distance is covered in this jump? Assume flat is ground.
(Answer: (a)15 ft/s, (b) 6.7 ft/s)

19. A projectile is fired in such a way that its horizontal range is equal to three times its maximum height. What is the angle of projection?
(Answer: 53.1°)

20. A projectile has an initial horizontal velocity of 40m/s at the edge of rooftop. Find the horizontal and vertical components of its velocity after 3s (Answer: 40m/s; -29.4m/s)/

Uniform circular motion

21. The space shuttle is in a circular orbit 220 km above Earth's surface and completes an Earth revolution every 89 min.
(a) What is the shuttle's speed?
(b) Its acceleration?
(Answer: (a) 7.8 km/s, (b) 9.1 m/s^2 toward Earth's center.)

22. A ball is attached to the end of 1.5m spring, and it swings in a circle with a constant speed of 8m/s. What is the centripetal acceleration?
(Answer: $42.7 m/s^2$).

1.2 Forces and Interactions

Questions

1. What is the difference between the second and third Newton's Laws?
2. Under what conditions is it possible to have a constant speed yet a nonzero acceleration?
3. A rubber ball is dropped onto the floor. What force causes the ball to bounce?

4. If the action and reaction forces are always equal in magnitude and opposite in direction to each other, then doesn't the net vector force on any object necessarily add up to zero? Explain your answer.
5. Describe a few examples in which the force of friction exerted on an object is in the direction of motion of the object.
6. Why we speak of a maximum force of static friction? Why we do not discuss a maximum force of kinetic friction?
7. Is the normal force acting on a body always equal to its weight?
8. According to what law you can conclude about the character of motion of a body when there is no net force acting on it?
9. A falling sky diver reaches terminal speed with her parachute closed. After the parachute is opened, what parameters change to decrease this terminal speed?
10. Why do bicyclists or motorcyclists "lean into" a curve?
11. What is the work of centripetal forces in uniform circular motion?
12. What is the difference between mass and weight?
13. Express dimensions of force in the basic dimensions (L, T, M – length, time, mass).
14. Distinguish clearly between the mass of an object and its weight and give the appropriate units for each in the SI system of units.
15. A round piece of brass found in the laboratory is labeled 500g. Is this its weight or its mass? How can you be sure?

Problems

1. In applying Newton's laws, we must identify the forces acting on an object Are there any forces acting on the following objects? If so, list them:
(a) the space shuttle in Earth orbit;
(b) an ice skater coasting on ice;
(c) the Voyager I spacecraft far past the orbit of the planet Pluto.
(Answer: (a) Force of gravity (toward Earth),
(b) force of gravity (down), normal force from the ice (Up); and a small friction force from the ice (opposite to the motion).
(c) essentially none)

2. In a tug of war, a red ribbon tied around a point on the rope between the two teams moves with a uniform velocity of 0.1 m/s in the y-direction. One team exerts a force on the rope of 600 N in the y-direction. What force does the other team exert on the rope?
(Answer: 600 N in the -y-direction)

3. In a classic demonstration, Otto von Guericke used 16 horses - 8 on each side-to try to pull apart two hemispheres forming a sphere from which air had been evacuated. Could he as well have used only 8 horses on one side with the other side tied to a sturdy tree?
(Answer: yes)

4. 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 400 m/s into a special resistive material. The bullet is stopped in a distance of 14 cm. 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?
(Answer: $-5.7\cdot10^5$ m/s^2; $-1.1\cdot10^3$ N)

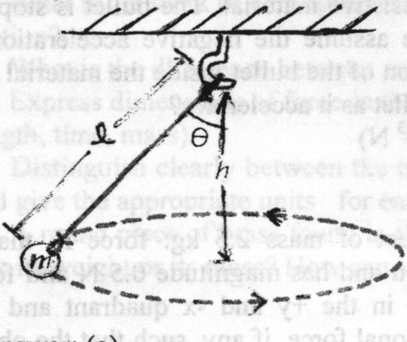
5. Two forces act on an object of mass 2.5 kg: force F_1 that is directed along the + x-direction and has magnitude 0.5 N and force F_2 that points at a 45° angle in the +y and -x quadrant and has magnitude 2 N. Find the additional force, if any, such that the object will accelerate in the +y-direction with magnitude 1.5 m/s^2
(Answer: (0.91 N)i + (2.3 N)j)

6. A car of mass 1150 kg accelerates from rest to 100 km/h in 11 s. With additional streamlining the same car undergoes acceleration to the same speed in 9.0 s. What is the difference in the force exerted by the air (the drag force) on the car in the two cases? For this problem, assume the drag force is constant. (This assumption is a poor one in practice.)
(Answer: $6.5\cdot10^2$ N)

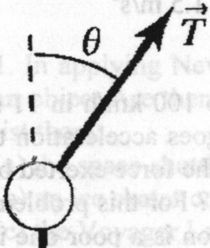
7. A falling automobile, mass 950 kg, has an acceleration of magnitude 9.8 m/s^2 when only the force of gravity acts on it. What is

the magnitude of the upward acceleration of Earth? Take the mass of Earth to be $6 \cdot 10^{24}$ kg.
(Answer: $1.6 \cdot 10^{-21}$ m/s^2)

8. Consider the conical pendulum, a mass on the end of a massless string, with the other end of the string fixed on a ceiling. Given the proper push, this pendulum can swing in a circle at a given angle Θ, maintaining the same height h throughout its swing, as shown in the figure below.
(a) What is the free-body diagram for such a pendulum?
(b) If the mass of the pendulum is 0.2 kg, the length of the pendulum is 50 cm, and the angle at which it swings is $\Theta = 10^0$, what is the speed of the mass as it swings?



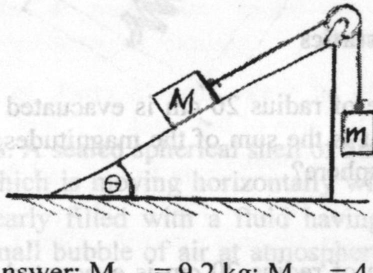
(Answer: (a)



(b) 0.4 m/s)

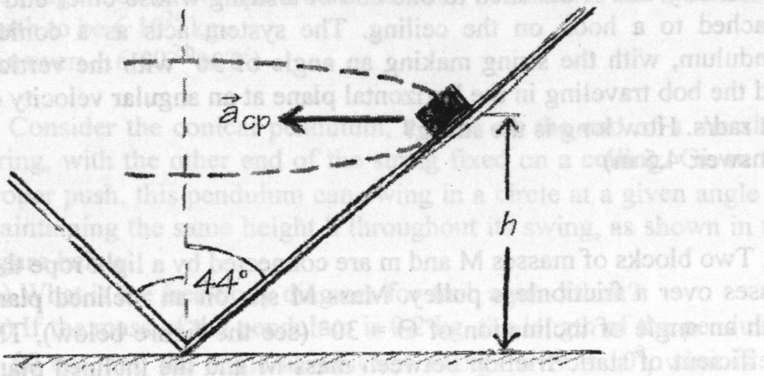
9. A heavy bob is attached to one end of a string whose other end is attached to a hook on the ceiling. The system acts as a conical pendulum, with the string making an angle of 30^0 with the vertical and the bob traveling in the horizontal plane at an angular velocity of $\pi/2$ rad/s. How long is the string?
(Answer: 4.5 m)

10. Two blocks of masses M and m are connected by a light rope that passes over a frictionless pulley. Mass M sits on an inclined plane with an angle of inclination of $\Theta = 30°$ (see the figure below), The coefficient of static friction between mass M and the inclined plane is 0.2, while m = 3 kg. Determine the largest and smallest possible values of M for which the system remains in equilibrium. Calculate the force of static friction on the block of mass M = 6 kg.



(Answer: M_{max} = 9.2 kg; M_{min} = 4.5 kg; 0)

11. A small block slides in a horizontal circle on the inside of a conical surface, with the cone making an angle of 44^0 with the vertical. Assuming that there is no friction between the block and the surface and the block slides with an angular speed of 3.8 rad/s, at what vertical height above the apex of the cone does the block slide?
(Answer: 0.72 m)



12. Find the mass and the weight of the body if a resultant force of 16N will give it an acceleration of $5 m/s^2$. (Ans. 3.20kg, 31.4N).

Hydrostatics

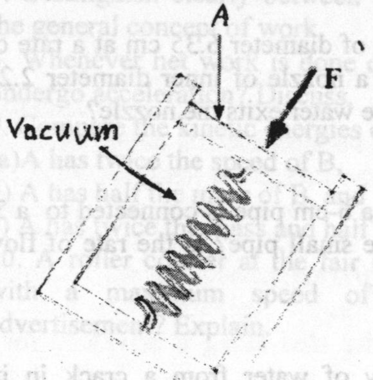
13. A hollow stainless steel sphere of radius 20 cm is evacuated so that there is a vacuum inside. What is the sum of the magnitudes of the forces that act to compress the sphere?
(Answer: $5.1 \cdot 10^4$ N)

14. A hollow stainless steel sphere of radius 20 cm is evacuated so that there is a vacuum inside. There is a circular hole of diameter 4 cm on the side of the sphere for access to the inside. Calculate the force needed to pull a flat plate off the hole when the sphere is evacuated.
(Answer: 1300 N)

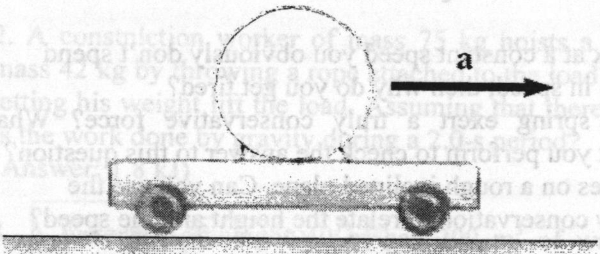
15. A 50 kg woman balances on one heel of a pair of high-heeled shoes. If the heel is circular and has a radius of 0.5 cm, what pressure does she exert on the floor?
(Answer: 6.24 MPa)

16. What is the total mass of the Earth's atmosphere? (The radius of the Earth is $6.37 \cdot 10^6$ m, and atmospheric pressure at the surface is $1.013 \cdot 10^5$ N/m^2.)
(Answer: $5.27 \cdot 10^{18}$ kg)

17. The spring of the pressure gauge shown in Figure below has a force constant of 1000 N/m, and the piston has a diameter of 2 cm. As the gauge is lowered into water, what change in depth causes the piston to move in by 0.5 cm? (Answer: 1.62 m)



18. A sealed spherical shell of diameter d is rigidly attached to a cart, which is moving horizontally with an acceleration a. The sphere is nearly filled with a fluid having density ρ and also contains one small bubble of air at atmospheric pressure. Determine the pressure P at the center of the sphere. (Answer: $P_0 + \frac{1}{2}\rho d\sqrt{g^2 + a^2}$)



Hydrodynamics

19. A large storage tank, open at the top and filled with water, develops a small hole in its side at a point 16 m below the water level. If the rate of flow from the leak is equal to $2.5\cdot10^{-3}$ m^3/min, determine
(a) the speed at which the water leaves the hole,
(b) the diameter of the hole.
(Answer: (a) 17.7 m/s; (b) 1.73 mm)

20. Water flows through a fire hose of diameter 6.35 cm at a rate of 0.0120 m^3/s. The fire hose ends in a nozzle of inner diameter 2.20 cm. What is the speed with which the water exits the nozzle?
(Answer: 31.6 m/s)

21. Water flowing at 6m/s through a 6-cm pipe is connected to a 3-cm pipe. What is the velocity in the small pipe? Is the rate of flow greater in the smaller pipe?
(Answer: 24m/s; no).

22. What is the emergent velocity of water from a crack in its container 6m below the surface? If the area of the crack is 1.3cm^2, at what rate of flow does water leave the container?
(Answer: 10.8m/s; $1.41\cdot10^{-3}$ m^3/s).

1.3 Work, Energy and Power.

Questions

1. When you walk at a constant speed you obviously don't spend energy on change in speed, then why do you get tired?
2. Does a real spring exert a truly conservative force? What experiment might you perform to check the answer to this question?
3. An object moves on a rough inclined plane. Can you use the concept of energy conservation to relate the height and the speed? How?

4. The center of mass of a championship-level high jumper passes below the bar even though the jumper passes above the bar. How is this possible?
5. Does the parabolic motion of projectiles apply to a missile traveling from a launch pad to a target area 5000 mi downrange?
6. If you have the misfortune to be in an automobile collision, you are better off in a more massive car (all other things being equal). Why?
7. Distinguish clearly between the physicist's concept of work and the general concept of work.
8. Whenever net work is done on a body, will the body necessarily undergo acceleration? Discuss.
9. Compare the kinetic energies of two bodies A and B if
(a)A has twice the speed of B,
b) A has half the mass of B, and
c) A has twice the mass and half the speed of B.
10. A roller coaster at the fair boasts "a maximum height of 100ft with a maximum speed of 60mi/h". Do you believe the advertisement? Explain.

Problems

1. A baseball of mass 145 g leaves a pitcher's hand at 96.6 mi/h, but, due to air resistance, it arrives at home plate 60.0 ft away traveling at 95.3 mi/h. Assume that the magnitude of the ball's acceleration is constant and that the ball travels in a straight line (ignore gravity). How much work is done by friction during the flight of the ball?
(Answer: -3.73 J)

2. A constnlction worker of mass 75 kg hoists a load of bricks of mass 42 kg by throwing a rope attached to the load over a pulley and letting his weight lift the load. Assuming that there no friction, what is the work done by gravity during a 2.0-s period?
(Answer: 1.8 kJ)

3. A waterfall of height 40 m has 200 m^3 of water falling every second. How many joules of work are done by gravity every hour?
(Answer: $2.8 \cdot 10^{11}$ J.)

4. A test car of mass 700 kg is moving at a speed of 15 mi/h when it crashes into a wall to test its bumper. If the car comes to rest in 0.3 s, how much average power is expended in the process?
(Answer: 52 kW)

5. A 7-kg rifle is used to fire a 10-g bullet that travels with a speed of 700 m/s.
(a) What is the speed of recoil of the rifle?
(b) How much energy does it transmit to the shoulder of the person using the rifle as it stops?
(Answer: (a) -1.0 m/s, (b) 3.5 J)

6. A fire rescue unit uses a tightly woven net to catch an 80-kg person who jumps out of a burning building from a height of 11 m. What is the impulse transmitted to the net? If the net sinks 70 cm as it slows down the jumper, what is the average force exerted on the jumper by the net?
(Answer: $-1174{,}66\cdot10^3$ kg·m/s, 12320,00 N;)

7. A horizontal force pushes a 10kg sled along a driveway for a distance of 40m. If the coefficient of sliding friction is 0.2, what work is done by the friction force?
(Answer: 784J).

8. An average force of 40N compresses a coiled spring a distance of 6cm. What is the work done by the 40N force? What work is done by the spring? What is the resultant work?
(Answer: 2.40J, -2.40J, 0).

9. A runaway 400kg wagon enters a cornfield with a velocity of 12m/s and eventually comes to rest. What work was done on the wagon?
(Answer: 28.8kJ).

10. What average force is needed to increase the velocity of a 2kg object from 5m/s to 12m/s over a distance of 8m?
(Answer: 14.9N).

11. At a particular instant a mortar shell has a velocity of 60m/s. If its potential energy at that point is one-half of its kinetic energy, what is its height above the earth?
(Answer: 91.8m).

1.4 Impulse and Momentum. Collisions

Questions

1. Discuss the vector nature of impulse and momentum
2. If you hold a weapon loosely when firing, it appears to give a greater kick than when you hold it tight against your shoulder. Explain. What effect does the weight of the weapon have?
3. A mortar shell explodes in midair. How is momentum conserved? How is energy conserved?
4. A farther and his daughter stand facing each other on a frozen pond. If the girl pushes her father backward, describe their relative motion and velocities. Would they differ if the father pushed the daughter?

Problems

1. A 0.2 kg baseball traveling to the left at 20m/s is driven in the opposite direction at 35m/s when it is hit by a bat. The average force on the ball is 6400N. How long was it in contact with the bat?
(Answer: 1.72ms).

2. A cue stick strikes an eight ball with an average force of 80N over a time of 12ms. If the mass of the ball is 200g, what will be its velocity?
(Answer: 4.80m/s).

3. A 20kg child is at rest in a wagon. The child jumps forward at 2m/s, sending the wagon backward at 12m/s. What is the mass of the wagon? (Answer: 3.33kg).

4. A 6kg bowling ball collides head on with 1.8kg pin. The pin moves forward at 3m/s and the ball slows to 1.6m/s. What was the initial velocity of the bowling ball?
(Answer: 2.50m/s).

Spring

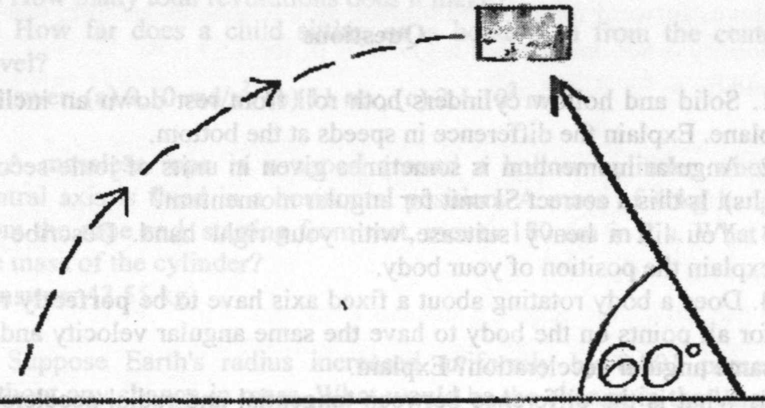
5. A spring gun is made by compressing a spring (assumed to be perfect) and latching it. A spring of constant $k = 60$ N/ m is used and the latch is located at a distance of 7 cm from equilibrium. The pellets have mass 4 g. What is the muzzle velocity of the gun?
(Answer: 8.6 m/s)

6. 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.
(Answer: 81 mJ)

Elastic and Inelastic Collisions

7. A billiard ball moving at 3.0 m/s collides with another billiard ball at rest. The balls move off at right angles to one another. If the first ball continues with a speed of 1.5 m/s, what is the speed of the ball that was initially at rest?
(Answer: 2.6 m/s)

8. In a target shooting game, wooden blocks are thrown into the air and shot in flight. A block of 0.80 kg has a speed of 10 m/s at the top of its trajectory when it is hit by a bullet from below at an angle of 60° from the horizontal. The mass of the bullet is 5.0 g and its speed is 550 m/s when it hits the block. The bullet is embedded in the block. What is the velocity of the
block immediately after impact?



(Answer: 8.7 m/s, 20° above the horizontal)

9. A block of mass 126 g is moving along the +x-axis with a speed of 0.875 m/s. Just ahead of it is a 9.66-kg mass moving in the same direction with the same speed. At some point, the large mass hits a wall and bounces off the wall perfectly elastically. What is the return speed of the small mass after its elastic collision with the large mass?
(Answer: 2.59 m/s)

10. A 2000kg truck traveling at 10m/s crashes into 1200kg car initially at rest. What is the common velocity after the collision if they stick together? What is the loss in kinetic energy?
(Answer: 6.25m/s, 37,500J).

11. A 20g object travelling to the left at 8m/s collides head on with a 10g object travelling to the right at 5m/s. What is their combined velocity after impact?
(Answer: 3.67m/s to the left).

12. The coefficient of restitution for steel is 0.90. If a steel ball is dropped from a height of 7m, how high will it rebound?
(Answer: 5.67m).

1.5 Rotation of Rigid Bodies

Questions

1. Solid and hollow cylinders both roll from rest down an inclined plane. Explain the difference in speeds at the bottom.
2. Angular momentum is sometimes given in units of joule-seconds (J·s). Is this a correct SI unit for angular momentum?
3. You lift a heavy suitcase with your right hand. Describe and explain the position of your body.
4. Does a body rotating about a fixed axis have to be **perfectly** rigid for all points on the body to have the same angular velocity and the same angular acceleration? Explain.
5. What is the difference between tangential and radial acceleration for a point on a rotating body?
6. How might you determine experimentally the moment of inertia of an irregularly shaped body about a given axis?
7. A cylindrical body has mass M and radius R. Can the mass be distributed within the body in such a way that its moment of inertia about its axis of symmetry is greater then MR^2 ? Explain.
8. When calculating the moment of inertia of an object, can we treat all its mass as if it were concentrated at the center of mass of the object? Justify your answer.

Problems

1. A centrifuge whose maximum rotation rate is 10000 rev/min can be brought to rest in 400 s.
(a) What is the average angular acceleration of the centrifuge?
(b) What is the distance that a point on the rim travels during the deceleration time assuming that the radius of the centrifuge is 8 cm and that the acceleration is uniform?
(Answer: (a) $-2.62\cdot10^2$ rad/s^2, (b) $1.67\cdot10^2$ m)

2. A carousel initially at rest has an angular acceleration of 0.4 rad/s^2 and accelerates for 5 s. It then rotates at a constant angular velocity for 30 s before slowing down at the same rate with which it accelerated.

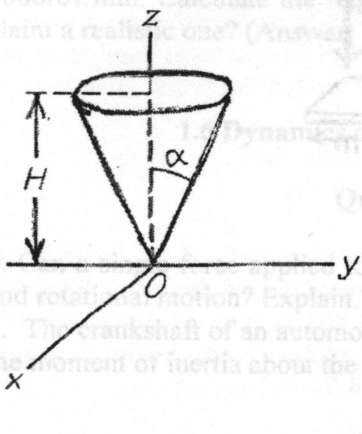
(a) What is the average acceleration during the first 20 s?
(b) How many total revolutions does it make?
(c) How far does a child sitting on a horse 3 m from the center travel?
(Answer: (a) 0.10 rad/s^2, (b) 11 rev, (c) $2.1\cdot10^2$ m)

3. A massless rope is wrapped around a hollow cylinder whose central axis is fixed in a horizontal position. A mass of 4 kg hangs from the rope and, starting from rest, moves 180 cm in 2 s. What is the mass of the cylinder?
(Answer: 43.55 kg)

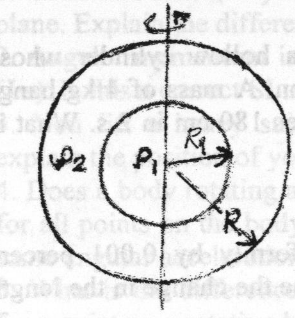
4. Suppose Earth's radius increased uniformly by 0.001 percent without any change in mass. What would be the change in the length of the day?
(Answer: 2 s)

5. A leather belt is wrapped around a pulley 20cm in diameter. A force of 60N is applied to the belt. What is a torque at the center of the shaft?
(Answer: 6N·m).

6. Calculate the rotational inertia about the central axis of the solid cone of mass M of opening half-angle α and height H.
(Answer: $(3/10)\cdot\tan^2(\alpha)MH^2$)



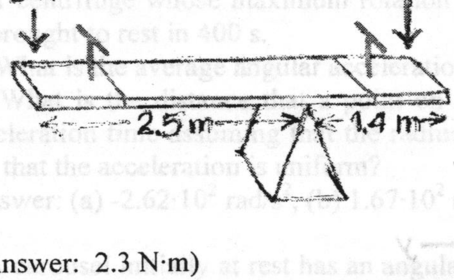
7. Calculate the rotational inertia of a sphere of radius R and mass M about an axis through the center of the sphere; assume that the density is not uniform but is given by ρ_1 for $0 \leq r \leq R_1$ and by ρ_2 for $R_1 \leq r \leq R$.



(Answer: $(8/15)\pi[(\rho_1 - \rho_2)R_1^5 + \rho_2 R^5]$.

8. A uniform rod of length L lies along the x-axis. A force F_{1y} is applied to one end of it and a force $-F_{2y}$ is applied to the other end of it. What is the magnitude and direction of the torque on the rod about its center of mass?
($L(F_{1y}, + F_{2y})/2$, perpendicular to the rod.)

9. A seesaw pivots as shown in below. What is the net torque about the pivot point?



(Answer: 2.3 N·m)

10. A cylindrical shell starting from rest rolls down an inclined plane that makes an angle of 20° with the horizontal. How far will the shell travel in 4 s?
(Answer: 13.4 m)

11. A solid cylinder starting from rest rolls down an inclined plane that makes an angle of 20° with the horizontal. How far will the cylinder travel in 4 s?
(Answer: 17.9 m.)

12. Weights of 2, 5, 8 and 10 N are hung from a 10m light rod at distance of 2, 4, 6 and 8m from the left end. How far from the left is the center of gravity?
(Answer: 6.08m).

13. An electric fan is turned off, and its angular velocity decreases uniformly from 500rev/min to 200rev/min in 4.00s.
(a)Find the angular acceleration in rev/s^2 and the number of revolutions made by the motor in the 4.00s interval,
(b) How many more seconds are required for the fan to come to rest if the angular acceleration remains constant at the value calculated in part (a)? (Answer: (a) -1.25rev/s^2; 23.3 rev,(b)2.67s).

14. An advertisement claims that a centrifuge takes up only 0.127m of bench space but can produce a radial acceleration of 3000g at 5000rev/min. Calculate the required radius of the centrifuge. Is the claim a realistic one? (Answer: 10.7cm; No).

1.6 Dynamics of Rotational Motion

Questions

1. Can a single force applied to a body change both its translational and rotational motion? Explain.
2. The crankshaft of an automobile engine has a flywheel to increase the moment of inertia about the rotation axis. Why is this desirable?

3. When you turn on an electric motor, it takes longer to come up to final speed if there is a grinding wheel attached to the shaft. Why?
4. Force A has a magnitude twice that of force B. Is it possible for force B to exert a greater torque on an object than force A?
5. The work done by a force is the product of force and distance. The torque due to a force is a product of force and distance. Does this mean that torque and work are equivalent? Explain.
6. A bullet emerges from a rifle spinning on its axis. Explain how this prevents the bullet from tumbling and keeps the streamlined end pointed forward.

Problems

1. A 2kg textbook rests on a frictionless horizontal surface. A cord attached to the book passes over a pulley whose diameter is 0.150m, to a hanging book with mass 3kg. The system is released from rest, and the books are observed to move 1.20m in 0.800s.
(a) What is the tension in each part of the cord?
(b) What is the moment of inertia of the pulley about its rotation axis?
(Answer: (a) 7.5N in horizontal part, 18.2N in hanging part;
(b) $0.0160\text{kg}\cdot\text{m}^2$).

2. (a) Compute the torque developed by an industrial motor whose output is 150kW at an angular speed of 4000rev/min.
(b) A drum with negligible mass, 0.400m in diameter is attached to the motor shaft and the power output of the motor is used to raise a weight hanging from a rope wrapped around the drum. How heavy a weight can the motor lift at constant speed?
(c) At what constant speed will the weight rise?
(Ans. a) 358N·m; b) $1.79\cdot10^3$N; c) 83.8m/s).

3. Find the magnitude of the angular momentum of the second hand on a clock about an axis through the center of the clock face. The clock hand has a length of 15.0cm and a mass of 6.0g. Take the second hand to be a slender rod rotating with constant angular velocity about one end. (Answer: $4.71\cdot10^{-6}$ kg/ $\text{m}^2\cdot\text{s}$).

Classical Physics
Mechanics
Individual Home Works I

Variants	Questions		Problems			
I	1.1.1	1.3.1	1.1.1	1.2.1	1.3.1	1.6.1
II	1.1.2	1.3.3	1.1.2	1.2.2	1.3.2	1.5.4
III	1.1.5	1.3.5	1.1.3	1.2.3	1.3.4	1.5.6
IV	1.1.6	1.3.7	1.1.4	1.2.4	1.3.5	1.5.2
V	1.1.7	1.3.8	1.1.5	1.2.5	1.3.6	1.5.10
VI	1.1.8	1.4.1	1.1.6	1.2.6	1.3.7	1.6.2
VII	1.1.9	1.4.2	1.1.7	1.2.7	1.3.8	1.5.14
VIII	1.1.10	1.4.3	1.1.8	1.2.8	1.3.9	1.5.1
IX	1.1.11	1.5.1	1.1.9	1.2.9	1.3.10	1.6.3
X	1.2.1	1.5.2	1.1.10	1.2.10	1.3.11	1.5.13
XI	1.2.2	1.5.3	1.1.11	1.2.11	1.4.1	1.5.7
XII	1.2.3	1.5.4	1.1.12	1.2.12	1.4.3	1.5.9
XIII	1.2.5	1.5.5	1.1.13	1.2.13	1.4.4	1.5.3
XIV	1.2.6	1.5.6	1.1.14	1.2.14	1.4.5	1.5.11
XV	1.2.8	1.5.7	1.1.15	1.2.15	1.4.6	1.5.4
XVI	1.2.10	1.5.8	1.1.16	1.2.16	1.4.8	1.5.8
XVII	1.2.11	1.6.1	1.1.17	1.2.17	1.4.9	1.6.1
XVIII	1.2.13	1.6.2	1.1.18	1.2.18	1.4.10	1.5.12
XIX	1.2.14	1.6.3	1.1.19	1.2.19	1.4.11	1.6.2
XX	1.2.15	1.6.5	1.1.20	1.2.20	1.4.12	1.5.5

2. Molecular Physics and Thermodynamics

Questions

1. Why should the amalgam used in dental fillings have the same average coefficient of expansion as a tooth? What would occur if they were mismatched?
2. What does the ideal gas law predict about the volume of a sample of gas at absolute zero temperature? Why is this prediction incorrect?
3. After food is cooked in a pressure cooker, why is it very important to cool off the container with cold water before attempting to remove the lid?
4. Metal lids on glass jars can often be loosened by running hot water over them. How is this possible?
5. Which of the following are reversible processes:
   a. the slow inflation of a balloon with a bicycle pump;
   b. the heating up of a drill bit used to bore a hole in a log;
   c. the slow stretching of a wire by an external force, carried out at a constant temperature?
6. Why is the latent heat of vaporization for water so much larger than the latent heat of fusion?
7. Why does perspiring during exercise help you to cool off?
8. Explain why a change in a thermal system is reversible if:
   a. there is no friction
   b. the change is carried out slowly.
9. Can we assign a temperature to a single molecule? Explain.
10. If you were to consider helium gas and air at the same temperature, which gas would have a higher root-mean-square momentum?
11. In cold or hot climates does heat pumps have higher COP?
12. Is it possible to cool a house by leaving a refrigerator door open? What would be the net effect if you were to leave the door open?
13. In the ideal-gas equation, could an equivalent Celsius temperature be used instead of the Kelvin one if an appropriate numerical value of the constant R is used? Why or why not?

14. When a car is driven some distance, the air pressure in the tires increases. Why? Should you let out some air to reduce the pressure? Why or why not?

15. How does evaporation of perspiration from your skin cool your body?

16. Which has more atoms, a kilogram of hydrogen or a kilogram of lead? Which has more mass? Explain.

17. The temperature of an ideal gas is directly proportional to the average kinetic energy of its molecules. If a container of ideal gas is moving past you at 2000m/s, is the temperature of the gas higher than if the container was at rest? Defend your answer.

18. In deriving the ideal-gas equation from the kinetic-molecular model, we ignored potential energy due to the earth's gravity. Is this omission justified? Why or why not?

19. If the root-mean-square speed of the atoms of an ideal gas is to be doubled, by what factor must the Kelvin temperature of the gas be increased? Explain.

20. Some elements that form solid crystals have molar heat capacities greater than 3R. What could account for this?

Problems

Molecules

1. Given that the molecular weight of water H_20 is 18 g/mol and that the volume occupied by 1.0 g of water is 1 cm^3, use Avogadro's number to find the distance between neighboring water molecules. Assume for simplicity that the molecules are stacked like cubes. (Answer: $3.1\cdot10^{-10}$ m.)

Equation of State of Ideal Gas

2. The pressure of an ideal gas in a closed container is 0.60 atm at 35°C, The number of molecules is $5.0\cdot10^{22}$.

(a) What is the pressure in pascals?

(b) What is the temperature in kelvins?
(d) What is the volume of the container?
(e) If the container is heated to 120°C, what is the pressure in the container in atmospheres?
(Answer: (a) $6.1\cdot10^4$ Pa; (b) 308K, (c) $3.5\cdot10^{-3}$ m^3, (d) 0.77 atm)

3. In an experiment, a vacuum of 10^{-10} atm is achieved in a bottle. If the bottle is at room temperature (30°C), what is the number of molecules in the bottle per cubic centimeter?
(Answer: $2.42\cdot10^9$ molecules)

4. An ideal gas is contained in a tank at 120 atm of pressure and 263K.
(a) If half the mass of gas is drawn off and the temperature then rises by 50K, what is the new pressure?
(b) Suppose instead that the temperature first rises by 50K and then half the mass of the gas is drawn off. What is the new pressure?
(Answer: (a) 71 atm, (b) 71 atm)

5. Calculate the volume of 24 g of the gaseous form of ethyl ether, $C_4H_{10}O$ at a temperature of 120K and pressure of 0.080 atm. Assume that the gas is ideal.
(Answer: 40 l)

6. A cylinder is closed at one end by a movable piston. The cylinder contains 300 cm^3 of air at 20°C and $1.0\cdot10^5$ Pa pressure. The cylinder undergoes the following changes:
(a) the gas is heated in such a way that its volume doubles but its pressure remains constant;
(b) the volume is kept constant and the temperature is changed until the pressure increases by 30 percent;
(c) the gas cools, and the piston position is adjusted to keep the pressure constant until the initial volume is reached. Calculate the volume, pressure, and temperature after each step.
(Answer: (a) $P_2 = 10^5$ Pa; $V_2 = 600$ cm^3; $T_2 = 568K$,
(b) $P_3 = 1.30\cdot10^5$ Pa; $V_3 = 600$ cm^3; $T_3 = 762K$,
(c) $P_4 = 1.30\cdot10^5$ Pa; $V_4 = 300$ cm^3; $T_4 = 381K$)

7. A room of volume V contains air having equivalent molar mass M (in g/mol). If the temperature of the room is raised from T_1 to T_2, what mass of air will leave the room? Assume that the air pressure in the room is maintained at P_0.

$$m_1 - m_2 = \frac{P_0 V M}{R}\left(\frac{1}{T_1} - \frac{1}{T_2}\right)$$

(Answer:)

8. Consider a tank of volume 0.30 m^3 containing 2.5 mol of helium gas at 20°C. If we add 1.0 mol of O_2 at 0°C to the helium and let the whole system come to equilibrium, what will the equilibrium temperature be? What will the pressure be?
(Answer: (a) 285K, (b) $2.8\cdot10^4$ Pa)

9. (a) Use the ideal gas law to estimate the number of air molecules in your physics lab room , assuming all the air is N_2.
(b) Calculate the particle density in the lab
(Answer: a) $3\cdot10^{27}$ molecules; b) $3\cdot10^{19}$ molecules/cm^3).

10. What is the volume of 3.0 moles of copper?
(Answer: 21.4 cm^3).

11. How many moles are there in a 1.0kg bottle of water? How many molecules? The molar mass of water is 18.0g/mol
(Answer: 55.6mol; $3.35\cdot10^{25}$ molecules).

12. (a) How much heat does it take to increase the temperature of 2.50mol of a diatomic ideal gas by 30.0K near room temperature if the gas is held at constant volume?
(b) What is the answer to the question in part a) if the gas is monatomic rather than diatomic?
(Answer: (a) 1560J; (b) 935J).

13. The speed of propagation of a sound wave in air at 27^0 C is about 350m/s. Calculate, for comparison,
(a) v_{rms} for nitrogen molecules;

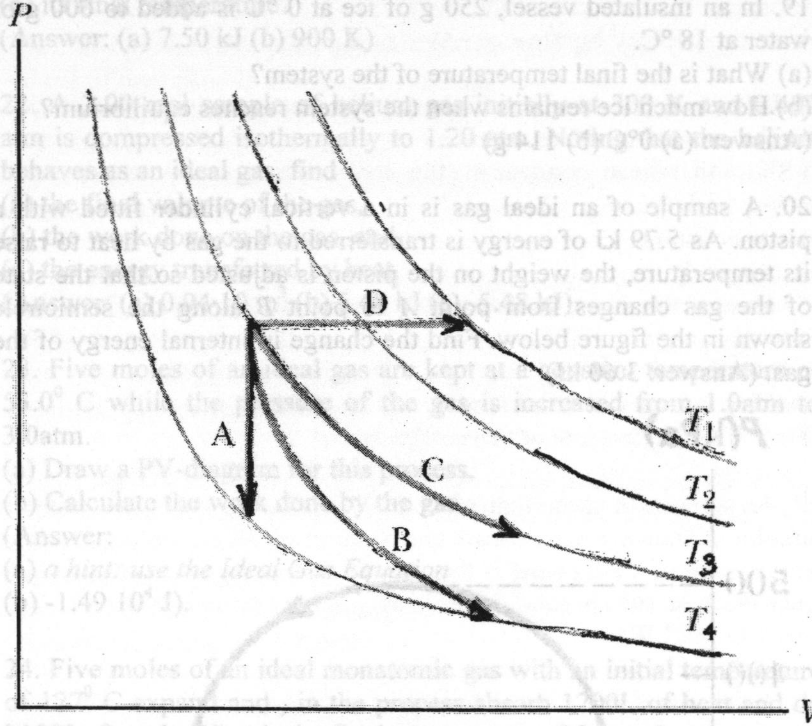
(b) the rms value of v_x at this temperature. The molar mass of nitrogen (N_2) is 28.0mol/g
(Answer: (a) 517m/s; (b)299m/s).

Van der Waals model

14. There is a certain temperature T_B (the Boyle temperature) for which a van der Waals gas behaves as if it were ideal.
(a) Show that an expression for this temperature is $T_B = (a/bR)\,[1 - (bn/V)]$.
(b) The constants a and b of the van der Waals equation of state are a = 0.140 $m^6 \cdot Pa/mol^2$ and b = $4.00 \cdot 10^{-5} m^3/mol$ for argon gas. What is the value of the Boyle temperature of argon gas when the gas is so dilute that the term bn/V in the expression for the Boyle temperature can be ignored?
(Answer: (a) Through the Van-der-Waals and Ideal gas equations. (b) 421K)

15. Measurements show that nitrogen gas obeys the van der Waals equation of state with the constant b = $3.94 \cdot 10^{-5}$ m^3 /mol. What is the size of a nitrogen molecule?
(Answer: $2.50 \cdot 10^{-10}$ m)

16. Characterize the paths in the figure below as isobaric, isovolumetric, isothermal, or adiabatic.



(Answer: A is isovolumetric, B is adiabatic, C is isothermal, and D is isobaric.)

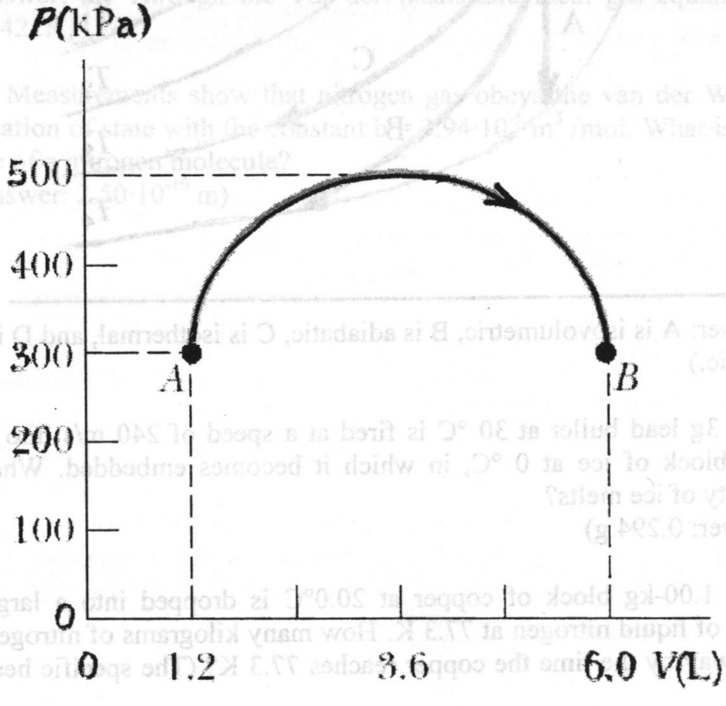
17. A 3g lead bullet at 30 °C is fired at a speed of 240 m/s into a large block of ice at 0 °C, in which it becomes embedded. What quantity of ice melts?
(Answer: 0.294 g)

18. A 1.00-kg block of copper at 20.0°C is dropped into a large vessel of liquid nitrogen at 77.3 K. How many kilograms of nitrogen boil away by the time the copper reaches 77.3 K? (The specific heat

of copper is 0.0920 cal/g· °C. The latent heat of vaporization of nitrogen is 48.0 cal/g.)
(Answer:0.414 kg)

19. In an insulated vessel, 250 g of ice at 0 °C is added to 600 g of water at 18 °C.
(a) What is the final temperature of the system?
(b) How much ice remains when the system reaches equilibrium?
(Answer: (a) 0°C (b) 114 g)

20. A sample of an ideal gas is in a vertical cylinder fitted with a piston. As 5.79 kJ of energy is transferred to the gas by heat to raise its temperature, the weight on the piston is adjusted so that the state of the gas changes from point *A* to point *B* along the semicircle shown in the figure below. Find the change in internal energy of the gas. (Answer: 3.60 kJ)



21. An ideal gas initially at 300 K undergoes an isobaric expansion at 2.50 kPa. If the volume increases from 1.00 m^3 to 3.00 m^3 and 12.5 kJ is transferred to the gas by heat, what are
(a) the change in its internal energy and
(b) its final temperature?
(Answer: (a) 7.50 kJ (b) 900 K)

22. A 2.00-mol sample of helium gas initially at 300 K and 0.400 atm is compressed isothermally to 1.20 atm. Noting that the helium behaves as an ideal gas, find
(a) the final volume of the gas,
(b) the work done on the gas, and
(c) the energy transferred by heat.
(Answer: (a) $0.04 \cdot 10$ m^3 (b) 5.48 kJ (c) -5.48 kJ)

23. Five moles of an ideal gas are kept at a constant temperature of 53.0^0 C while the pressure of the gas is increased from 1.0atm to 3.0atm.
(a) Draw a PV-diagram for this process.
(b) Calculate the work done by the gas
(Answer:
(a) *a hint: use the Ideal Gas Equation*
(b) $-1.49\ 10^4$ J).

24. Five moles of an ideal monatomic gas with an initial temperature of 127^0 C expand and , in the process absorb 1200L of heat and do 2100J of work. What is the final temperature of the gas?
(Answer: 113^0 C).

Heat Engine, Entropy

25. A 1 500-kg car is moving at 20.0 m/s. The driver brakes to a stop. The brakes cool off to the temperature of the surrounding air, which is nearly constant at 20.0°C. What is the total entropy change?
(Answer: 1.02 kJ/K)

26. A power plant, having a Carnot efficiency, produces 1 000 MW of electrical power from turbines that take in steam at 500 K and reject water at 300 K into a flowing river. The water downstream is 6 K warmer due to the output of the power plant. Determine the flow rate of the river.
(Answer: $5.97 \cdot 10^4$ kg/s)

27. What is the maximum efficiency of a steam engine whose boiler (the hottest-temperature reservoir in contact with the engine) is at 160°C and whose condenser (the coldest-temperature reservoir in contact with the engine) is at 35°C?
(Answer: 29%)

28. An inventor claims to have built an engine that takes in $3 \cdot 10^8$ J of thermal energy at 450K, rejects $1.4 \cdot 10^8$ J of thermal energy at 250K, and delivers $1 \cdot 10^8$ J of work in 1 h of cyclic operation. Is there anything wrong with this claim?
(Hint: *Use the first law of thermodynamics*)

29. An air conditioner is rated at 8000 Btu/h. Assuming maximum possible efficiency, an exhaust temperature of 38°C, and an interior temperature of 22°C, what is the electrical power consumption? (The work done on the air conditioner is supplied by electricity.)
(Answer: 127 W)

30. A refrigerator with coefficient of performance $K_{ref} = 5.1$ gives rise to a heat flow out of the cooling compartment at a rate of 400 cal/min. What is the required power of the motor that operates this refrigerator?
(Answer: 5.5 W)

31. One end of a metal rod is in contact with a thermal reservoir at 1273K and the other end is in contact with a reservoir at 293K. If the rate at which heat flow passes from the hot end to the cold end is 30 J/min, what is the rate of total entropy change? Is the process reversible? - explain
(Answer: $7.9 \cdot 10^{-2}$ J/K·min; irreversible)

32. Five moles of an ideal gas is in thermal isolation and undergoes free expansion from 35 L to 100 L. What is the entropy change of the gas? of the universe?
(Answer: ΔS_{gas} = 44 J/K; $\Delta S_{universe}$ = 44 J/K)

33. Fifty grams of oxygen gas at 320K do 80 J of work while 40 cal of heat flow is absorbed by the gas.
(a) What is the change in internal energy?
(b) In the temperature of the gas?
(c) In entropy, assuming that the change is isobaric?
(Answer: (a) 87 J, (b) 2.7K, (c) 0.38 J/K)

34. A diesel engine performs 2200J of mechanical work and discards 4300J of heat each cycle.
(a) How much heat must be supplied to the engine in each cycle?
(b) What is the thermal efficiency of the engine?
(Answer: (a) 6500J. (b) 34%).

35. A certain nuclear-power plant has a mechanical-power output (used to drive an electric generator) of 330MW. Its rate of heat input from the nuclear reactor is 1300MW.
(a) What is the thermal efficiency of the system?
(b) At what rate is heat discarded by the system?
(Answer: (a) 25%. (b) 970MW).

36. A window air-conditioner unit absorbs $9.8 \cdot 10^4$J of heat per minute from the room being cooled and in the same time period deposits $1.44 \cdot 10^5$J of heat into the outside air.
(a) What is the power consumption of the unit in watts?
(b) What is the energy efficiency rating of the unit?
(Answer: (a) 767W; (b) 7.27).

37. An ideal Carnot engine operates between 500°C and 100°C with a heat input of 250J per cycle. What minimum numbers of cycles are necessary for the engine to lift a 500kg rock through a height of 100m?
(Answer: 3790 cycles).

38. Calculate the entropy change that occurs when 1.0kg of water at 20.0^0 C is mixed with 2.0kg of water at 80.0^0 C
(Answer: 47.4J/K).

39. Two moles of an ideal gas undergo a reversible isothermal expansion from $0.0280m^3$ to $0.0420m^3$ at temperature of 25.0^0 C. What is the change in entropy of the gas?
(Answer: 6.74J/K).

40. A 0.0500kg cube of ice at an initial temperature of -15.0^0C is placed in 0.600kg of water at $T=45.0^0$C in an insulated container of negligible mass. Calculate the change in entropy of the system.
(Answer: 10.5J/K).

Classical Physics
Molecular Physics and Thermodynamics
Individual Home Works II

Variants	Questions		Problems			
I	2.1	2.10	2.01	2.06	2.13	2.33
II	2.3	2.12	2.02	2.07	2.14	2.34
III	2.5	2.14	2.03	2.08	2.15	2.35
IV	2.7	2.16	2.04	2.09	2.16	2.36
V	2.9	2.18	2.05	2.10	2.17	2.37
VI	2.11	2.20	2.06	2.11	2.18	2.38
VII	2.13	2.2	2.07	2.12	2.19	2.39
VIII	2.15	2.4	2.08	2.13	2.20	2.40
IX	2.17	2.6	2.09	2.14	2.21	2.01
X	2.19	2.8	2.10	2.15	2.22	2.02
XI	2.2	2.11	2.11	2.16	2.23	2.03
XII	2.4	2.13	2.12	2.17	2.24	2.04
XIII	2.6	2.15	2.13	2.18	2.25	2.05
XIV	2.8	2.17	2.14	2.19	2.26	2.06
XV	2.10	2.19	2.15	2.20	2.27	2.07
XVI	2.12	2.1	2.16	2.21	2.28	2.08
XVII	2.14	2.3	2.17	2.22	2.29	2.09
XVIII	2.16	2.5	2.18	2.23	2.30	2.10
XIX	2.18	2.7	2.19	2.24	2.31	2.11
XX	2.20	2.9	2.20	2.25	2.32	2.12

3. Electricity

Questions

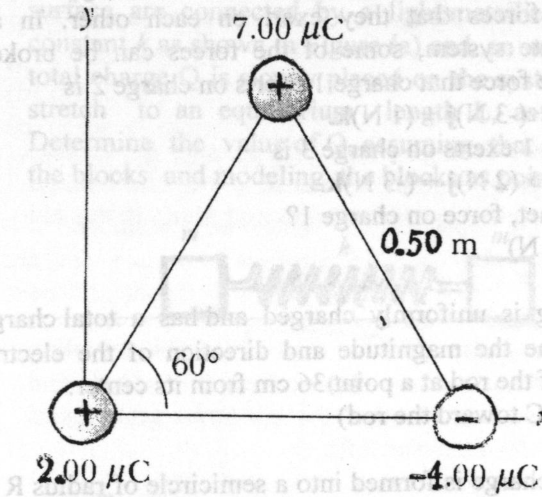
1. A balloon rubbed on a sweater and placed on a wall will often stay on the wall for a while. Explain how this happens.
2. How is the existence of a battery, which sends negative charges out of one of its contact points, consistent with the conservation of charge?
3. Consider a uniform, spherical positive charge distribution. A negative charge is placed at the center. Discuss the net force on that point charge. Discuss what happens to the point charge if it is placed a bit off center.
4. Why can't two electric field lines cross?
5. Two charges of opposite polarities are close together, Five times as many field lines leave one charge as end up on the other charge. What is the ratio of charges?
6. Use Gauss' law to show that electric field lines must be continuous and must originate from and end on charges.
7. Describe the way in which Gauss' law would fail if the field of a point charge were to decrease as $1/r$ rather than as $1/r^2$.
8. What is the force on a charge Q that is just inside a shell of uniformly distributed charge?
9. A region in space has a uniform electric field. What can we say about whether or not any charges are inside the region?
10. The potential of a configuration of point charges is zero at certain points. Does this mean that the force on a test charge is zero at these points?
11. What happens if you short out (connect with a conductor) the two plates of a large, charged capacitor? Could this be dangerous?
12. When you throw a switch and charge flows in a household wire, does the wire become charged?
13. What sense does it make to draw a circuit diagram with resistanceless wires when real wires always have some resistance?
14. Some of the free electrons in a good conductor (such as a piece of copper) move at speeds of 10^6 m/s or more. Why do these electrons not fly out of the conductor completely?

15. Two identical metal objects are mounted on insulating stands. Describe how you could place charges of opposite sign but exactly equal magnitude on the two objects.
16. What similarities do electrical forces have to gravitational forces? What are the most significant differences?
17. A certain region of space bounded by an imaginary closed surface contains no charge. Is the electric field always zero everywhere on the surface? If not, under what circumstances is it zero on the surface?
18. If the electric field of a point charge were proportional to $1/r^3$ instead of $1/r^2$, would Gauss's law still be valid? Explain your reasoning. (Hint: Consider a spherical Gaussian surface centered on a single point charge).
19. A student asked, "Since electrical potential is always proportional to potential energy, why bother with the concept of potential at all?" How would you respond?
20. If the electric potential at a single point is known, can **E** at that point be determined? If so, how? If not, why not?
21. Are there cases in electrostatics in which a conducting surface is not an equipotential surface? If so, give an example. If not, explain why not.

Electric Field and Electric Forces. Gauss's Law

1. What are the magnitude and direction of the electric field that will balance the weight of
(a) an electron and
(b) a proton?
(Answer: (a) 55.8 pN/C down (b) 102 nN/C up)

2. Three point charges are located at the corners of an equilateral triangle as shown in the figure below. Calculate the resultant electric force on the 7 μC charge. (Answer: 0.872 N at 330°)

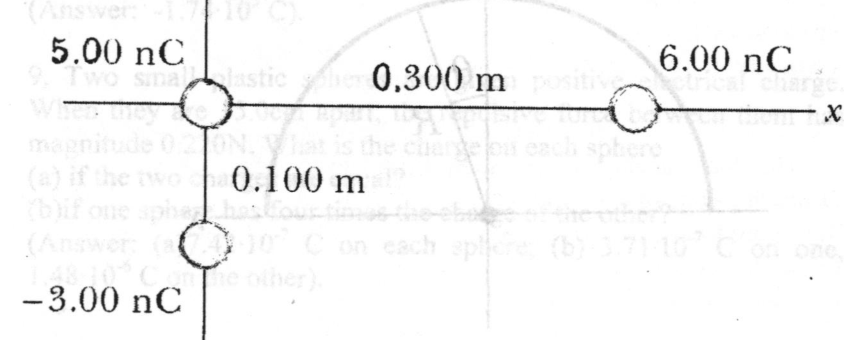


3. Three point charges are arranged as shown in the figure below

(a) Find the vector electric field that the 6 nC and -3 nC charges together create at the origin.

(b) Find the vector force on the 5 nC charge.

(Answer: (a) (-0.599**i** - 2.70**j**) kN/C (b) (-3.00i -13.5**j**) μN)



4. Three charges move through space with no forces acting on them except the electric forces that they exert on each other. In an appropriate coordinate system, some of the forces can be broken down as follows: The force that charge 1 exerts on charge 2 is

$\mathbf{F}_{21} = (2\text{ N})\mathbf{i} + (-3\text{ N})\mathbf{j} + (1\text{ N})\mathbf{k}.$

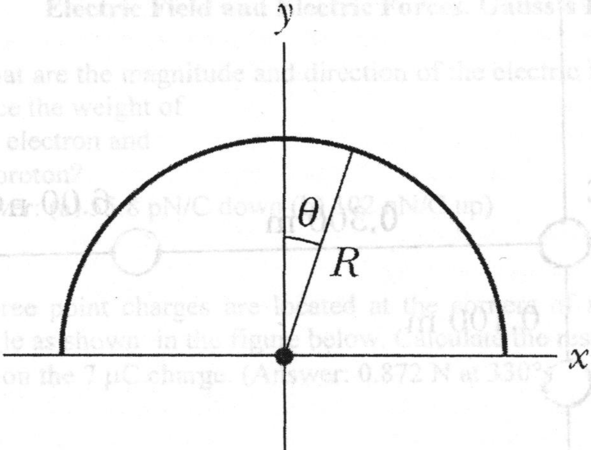
The force that charge 1 exerts on charge 3 is

$\mathbf{F}_{31} = (-3\text{ N})\mathbf{i} + (2\text{ N})\mathbf{j} + (-3\text{ N})\mathbf{k}.$

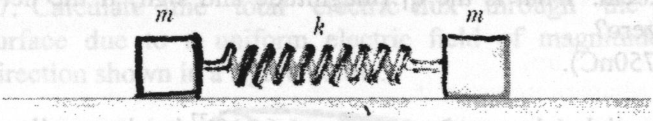
What is the total, or net, force on charge 1?
(Answer: $(\mathbf{i} + \mathbf{j} + 2\mathbf{k})$ N)

5. A rod 14 cm long is uniformly charged and has a total charge of -22 μC. Determine the magnitude and direction of the electric field along the axis of the rod at a point 36 cm from its center.
(Answer: $1.59 \cdot 10^6$ N/C toward the rod)

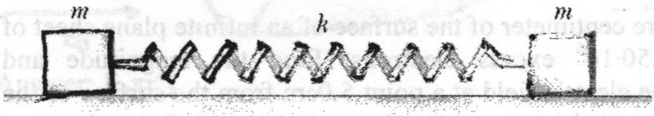
6. A line of positive charge is formed into a semicircle of radius R = 60.0 cm as shown in a figure below. The charge per unit length along the semicircle is described by the expression $\lambda = \lambda_0 \cos\theta$. The total charge on the cemicircle is 12.0 μC. Calculate the total force on a charge of 3.00 μC
placed at the center of curvature.
(Answer: -707jmN)



7. Two identical metallic blocks resting on a frictionless horizontal surface are connected by a light metallic spring having a spring constant k as shown in Figure (a) and an unstretched length L_i. A total charge Q is slowly placed on the system, causing the spring to stretch to an equilibrium length L, as shown in Figure (b). Determine the value of Q, assuming that all the charge resides on the blocks and modeling the blocks as point charges.



(a)



(b)

(Answer: $Q = 2L\sqrt{\dfrac{k(L - L_i)}{k_e}}$)

8. What is the total charge, in coulombs, of all the electrons in 1.80mol of hydrogen atoms?
(Answer: $-1.74\cdot 10^{5}$ C).

9. Two small plastic spheres are given positive electrical charge. When they are 15.0cm apart, the repulsive force between them has magnitude 0.220N. What is the charge on each sphere
(a) if the two charges are equal?
(b)if one sphere has four times the charge of the other?
(Answer: (a)$7.42\cdot 10^{-7}$ C on each sphere; (b) $3.71\cdot 10^{-7}$ C on one, $1.48\cdot 10^{-6}$ C on the other).

10. How far does the electron of a hydrogen atom have to be removed from the nucleus for the force of attraction to equal the weight of the electron at the surface of the earth?
(Answer: 5.08m).

11. Three point charges are arranged on a line. Charge q_3=+5.0nC and is at the origin. Charge q_2 =-3.0nC and is at x=+4.0cm. Charge q_1 is at x=+2.0cm. What is the q_1 (magnitude and sign) if the net force on q_3 is zero?
(Answer: +0.750nC).

12. An alpha particle (charge +2e and mass $6.64 \cdot 10^{-27}$ kg) is traveling to the right at 1.50km/s. What uniform electric field (magnitude and direction) is needed to cause it to travel to the left at the same speed after 2.65μs? (Answer: 23.5N/C, to the left).

13. Each square centimeter of the surface of an infinite plane sheet of paper has $2.50 \cdot 10^{6}$ excess electrons. Find the magnitude and direction of the electric field at a point 5.0cm from the surface of the sheet, if the sheet is large enough to be treated as an infinite plane
(Answer: 226N/C, toward sheet).

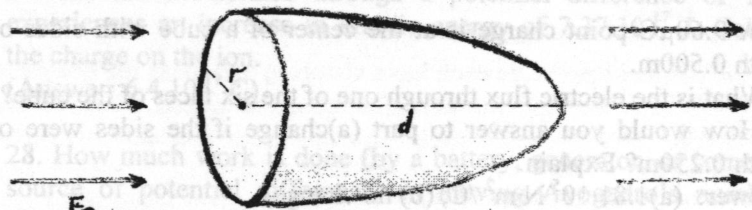
Charge and Electric Flux

14. A 40 cm diameter loop is rotated in a uniform electric field until the position of maximum electric flux is found. The flux in this position is measured to be $5.2 \cdot 10^{5}$ N·m²/C. What is the magnitude of the electric field?
(Answer: 4.14 MN/C)

15. A uniform electric field **ai** + **bj** intersects a surface of area *A*. What is the flux through this area if the surface lies
(a) in the yz plane?
(b) in the xz plane?
(c) in the xy plane?
(Answer: (a) aA (b) bA (c) 0)

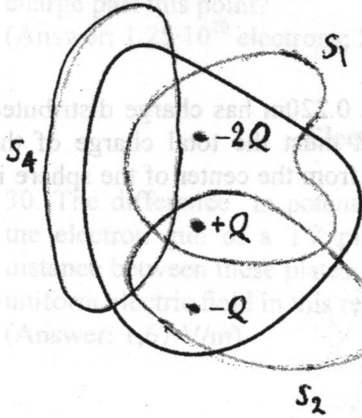
16. A uniform electric field aj + bk intersects a surface of area A. What is the flux through this area if the surface lies
(a) in the yz plane?
(b) in the xz plane?
(c) in the xy plane?
(Answer: (a) 0 (b) aA (c) bA)

17. Calculate the total electric flux through the paraboloidal surface due to a uniform electric field of magnitude E_0 in the direction shown in a figure below.



(Answer: $E_0\pi r^2$)

18. Four closed surfaces, S_1 through S_4, together with the charges -2Q , Q , and --Q are sketched in a figure below. (The colored lines are the intersections of the surfaces with the page.) Find the electric flux through each surface. (Answer: -Q /ε_0 for S1; 0 for S2; -2Q /ε_0 for S3; 0 for S4)



19. Determine the magnitude of the electric field at the surface of a lead-208 nucleus, which contains 82 protons and 126 neutrons. Assume the lead nucleus has a volume 208 times that of one proton, and consider a proton to be a sphere of radius 1.20·fm.
(Answer: $2.33 \cdot 10^{21}$N/C)

20. A large flat horizontal sheet of charge has a charge per unit area of 9.00 $\mu C/m^2$. Find the electric field just above the middle of the sheet.
(Answer: 508 kN/C up)

21. A 9.60μC point charge is at the center of a cube with sides of length 0.500m.
(a) What is the electric flux through one of the six faces of the cube?
(b) How would you answer to part (a)change if the sides were of length 0.250m? Explain.
(Answer: (a)$1.81 \cdot 10^5$ N·m^2 /C; (b) no change)

22. A sphere centered at the origin has radius 0.200m. A -5.00μC point charge is on the x-axis at x=0.300m. The net flux trough the sphere is 360 N·m^2 /C. What is total charge inside the sphere?
(Answer: 3.19nC).

23. How many excess electrons must be added to an isolated spherical conductor 32.0cm in diameter to produce an electric field of 1150N/C just outside the surface?
(Answer: $2.04 \cdot 10^{10}$).

24. An insulating sphere with radius 0.220m has charge distributed uniformly through its volume. What must the total charge of the sphere be if the electric field 0.110m from the center of the sphere is 950N/C?
(Answer: 10.2nC).

Motion of Charged Particles in Electric Field

25. Calculate the speed of a proton that is accelerated from rest through a potential difference of 120 V.
(Answer: 152 km/s)

26. Calculate the speed of an electron that is accelerated through the a potential difference of 120 V.
(Answer: 6.49 Mm/s)

27. An ion accelerated through a potential difference of 115 V experiences an increase in kinetic energy of $7.37 \cdot 10^{-17}$ J. Calculate the charge on the ion.
(Answer: $6.4\ 10^{-19}$ C)

28. How much work is done (by a battery, generator, or some other source of potential difference) in moving Avogadro's number of electrons from an initial point where the electric potential is 9.00 V to a point where the potential is 15.00 V? (The potential in each case is measured relative
to a common reference point.)
(Answer: 1.35 MJ)

29. How many electrons pass a point every second in a wire carrying a current of 20A? How much time is needed to transport 40C of charge past this point?
(Answer: $1.25 \cdot 10^{20}$ electrons; 2s).

Electric Potential

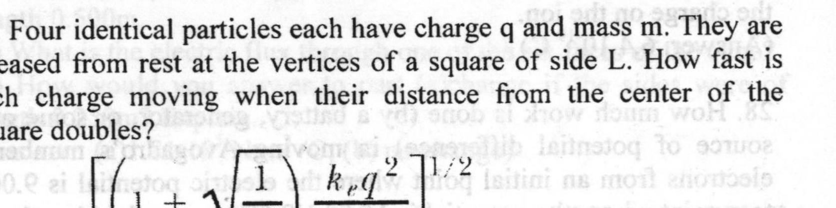
30. The difference in potential between the accelerating plates in the electron gun of a TV picture tube is about 25 000 V. If the distance between these plates is 1.5 cm, what is the magnitude of the uniform electric field in this region?
(Answer: 1,67 V/m)

31. An electron starts from rest 3 cm from the center of a uniformly charged insulating sphere of radius 2.00 cm and total charge 1.00 nC. What is the speed of the electron when it reaches the surface of the sphere?
(Answer: 7.26 Mm/s)

32. A uniform electric field of magnitude 325 V/m is directed in the negative y direction. The coordinates of point A are (-0.2, -0.3) m, and those of point B are (0.4, 0.5) m. Calculate the potential difference V_B- V_A.
(Answer: 260V)

33. Four identical particles each have charge q and mass m. They are released from rest at the vertices of a square of side L. How fast is each charge moving when their distance from the center of the square doubles?
(Answer: $\left[\left(1+\sqrt{\frac{1}{8}}\right)\frac{k_e q^2}{mL}\right]^{1/2}$)

34. A wire having a uniform linear charge density λ is bent into the shape shown in Figure below. Find the electric potential at point O.



(Answer: $k_e\lambda(\pi + 2\ln 3)$)

35. A point charge has a charge of $2.50\cdot10^{-11}$C. At what distance from the point charge is the electric potential
(a) 90.0V?

(b) 30.0V? Take the potential to be zero at an infinite distance from the charge
(Answer: (a)2.50mm; (b)7.49mm).

36. (a) An electron is to be accelerated from $3.00 \cdot 10^6$ m/s to $8 \cdot 10^6$ m/s. Through what potential difference must the electron pass to accomplish this?
(b) Through what potential difference must the electron pass if it is to be slower from $8 \cdot 10^6$ m/s to a halt?
(Answer: (a) increase of 156V, (b) decrease of 182V).

37. A potential difference of 4.75kV is established between parallel plates in air.
(a) If the air becomes electrically conducting when the electric field exceeds $3.00 \cdot 10^6$V/m, what is the minimum separation of the plates?
(b) When the separation has the minimum value calculated in part (a), what is the surface charge density on each plate?
(Answer: (a) 1.58mm; (b) $2.66 \cdot 10^{-5}$ C/m^2).

Current, Resistance and Electromotive Force

Direct-Current Circuits

38. In a particular cathode ray tube, the measured beam current is 30 μA. How many electrons strike the tube screen every 40 s?
(Answer: $7.50 \cdot 10^{15}$ electrons)

39. A small sphere that carries a charge q is whirled in a circle at the end of an insulating string. The angular frequency of rotation is ω. What average current does this rotating charge represent?
(Answer: $q\omega/(2\pi)$)

40. What emf is required to pass 60mA through a resistance of 20kΩ? If this same emf is applied to a resistance of 300Ω, what will be the new current? (Answer: 1200V; 4A).

41. A 120-V motor draws a current of 4.0A. How many joules of electrical energy are used in 1 h? How many kilowatt-hours?
(Answer: 1.73MJ; 0.48kWh).

42. A 115-V source of emf is attached to a heating element that is a coil of nichrome wire ($\rho=100\cdot10^{-8}\ \Omega\cdot m$) of cross section $1.20mm^2$. What must be the length of the wire if the resistive power loss is to be 800W?
(Answer: 19.8m).

43. The copper windings of a motor experience a 20 percent increase in resistance over their value at 20^0 C. What is the operating temperature? ($\alpha= 0.0043/C^0$)
(Answer: 66.5^0 C).

Battery

44. A battery has an emf of 15.0 V. The terminal voltage of the battery is 11.6 V when it is delivering 20.0 W of power to an external load resistor R.
(a) What is the value of R?
(b) What is the internal resistance of the battery?
(Answer: (a) 6.73 Ω; (b) 1.97 Ω)

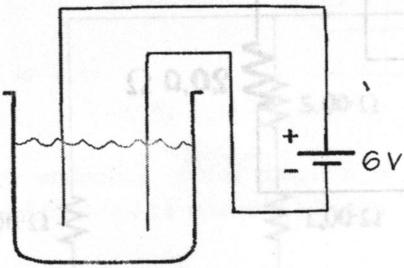
45. An 18-Ω resistor and a 9-Ω resistor are first connected in parallel and then in series with a 24-V battery. What is the effective resistance for each connection? Neglecting internal resistance, what is the total current delivered by the battery in each case?
(Answer: 6.00Ω, 27.0Ω; 4.00A, 0.899A).

Resistors

46. A toaster is rated at 600 W when connected to a 120 V (rms) source. What current does the toaster carry, and what is its resistance? (Answer: 5 A, 24 Ω)

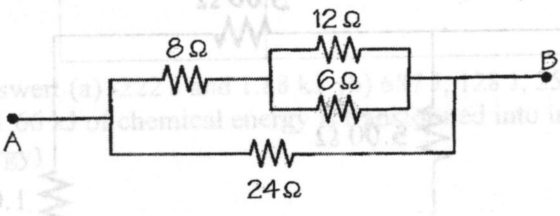
47. Suppose that a voltage surge produces 140 V for a moment. By what percentage does the power output of a 120 V, 100 W lightbulb increase? Assume that its resistance does not change.
(Answer: 36.1%)

48. A 6-V battery is connected to two metal wires dipped in a pot of water. A current of 50 mA flows for 18 h. How much energy is taken out of the battery during that time?



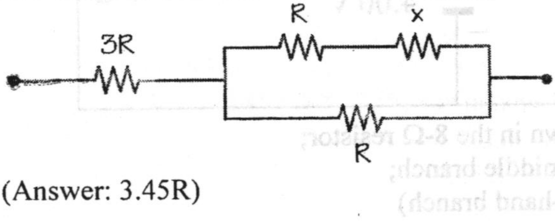
(Answer: 5.4 kWh)

49. Calculate the current in each resistor, given that $V_{AB} = 36$ V.



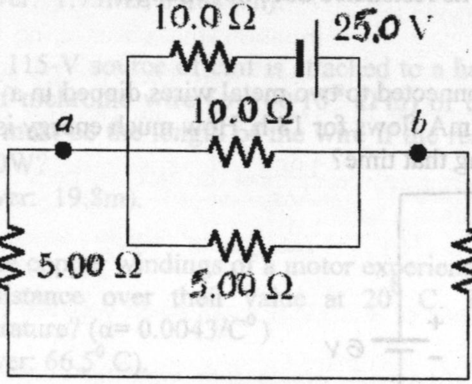
(Answer: 6Ω - 2A, 8Ω - 3A, 12Ω - 1A, 24Ω - 1.5A)

50. What must the value of the resistance x of the unknown resistor be so that the total equivalent resistance of the network is also x?



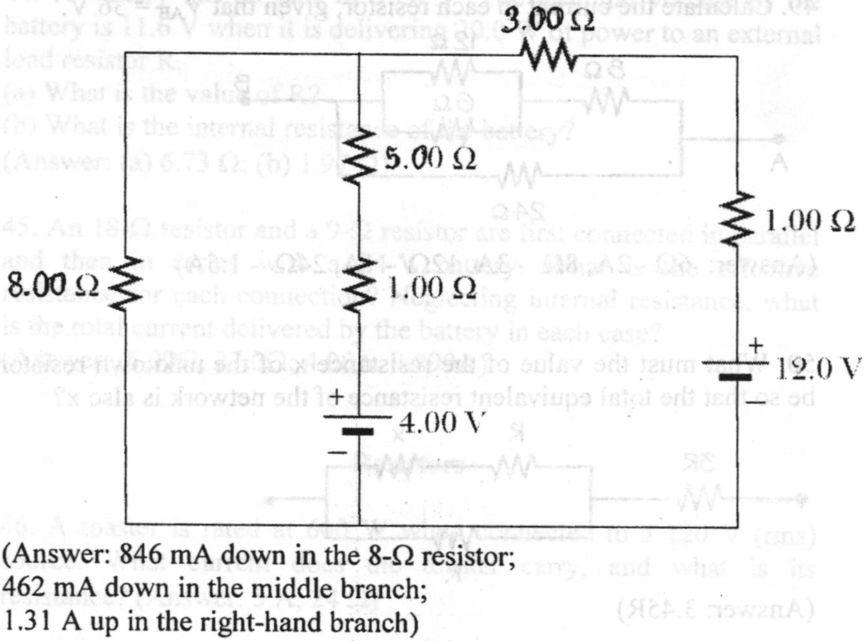
(Answer: 3.45R)

51. (a) Find the current in the 20-Ω resistor
(b) Find the potential difference between points a and b.



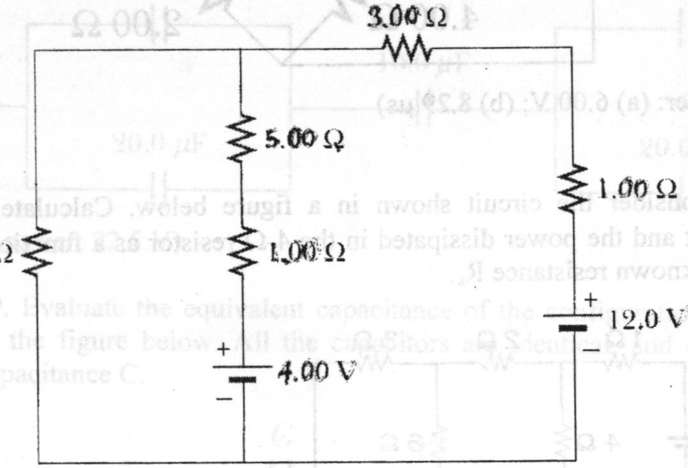
(Answer: (a) 227 mA, (b) 5.68 V)

52. Determine the current in each branch of the circuit.



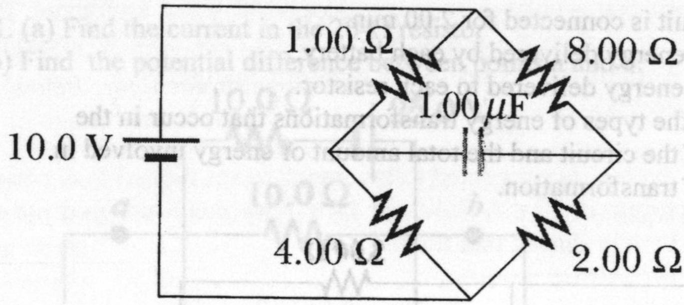
(Answer: 846 mA down in the 8-Ω resistor;
462 mA down in the middle branch;
1.31 A up in the right-hand branch)

53. The circuit is connected for 2.00 min.
(a) Find the energy delivered by each battery.
(b) Find the energy delivered to each resistor.
(c) Identify the types of energy transformations that occur in the operation of the circuit and the total amount of energy involved in each type of transformation.



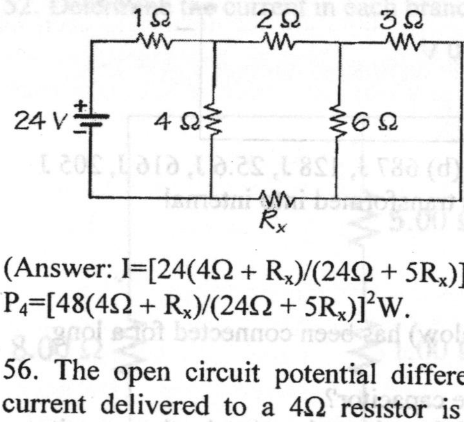
(Answer: (a) -222 J and 1.88 kJ (b) 687 J, 128 J, 25.6 J, 616 J, 205 J (c) 1.66 kJ of chemical energy is transformed into internal energy)

54. The circuit (see the figure below) has been connected for a long time.
(a) What is the voltage across the capacitor?
(b) If the battery is disconnected, how long does it take the capacitor to discharge to one tenth of its initial voltage?



(Answer: (a) 6.00 V; (b) 8.29 μs)

55. Consider the circuit shown in a figure below. Calculate the current and the power dissipated in the 4-Ω resistor as a function of the unknown resistance R_x.

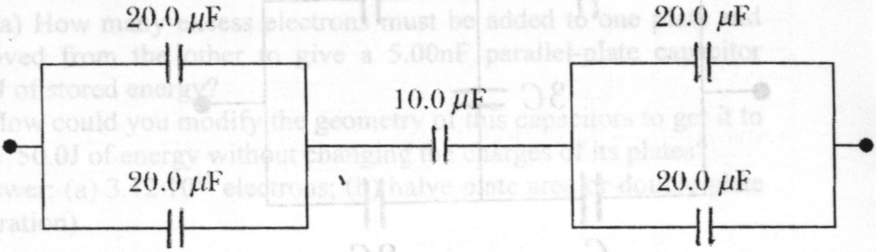


(Answer: $I=[24(4\Omega + R_x)/(24\Omega + 5R_x)]$A;
$P_4=[48(4\Omega + R_x)/(24\Omega + 5R_x)]^2$W.

56. The open circuit potential difference of a battery is 6V. The current delivered to a 4Ω resistor is 1.40A. What is the internal resistance?
(Answer: 0.286Ω).

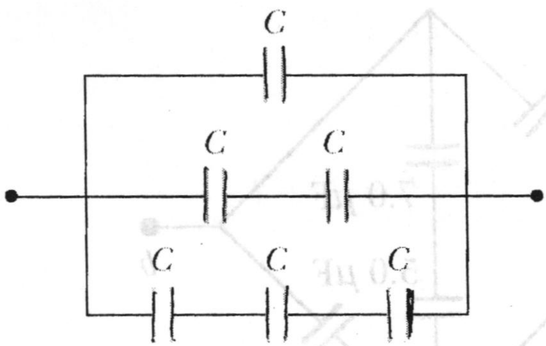
57. An aluminum cube has a side length of 1.80m. What is the resistance between two opposite faces of the cube?
(Answer: $1.53\cdot10^{-8}$ Ω).

58. Each capacitor in the combination shown in the figure below has a breakdown voltage of 15 V. What is the breakdown voltage of the combination?



(Answer: 22.5 V)

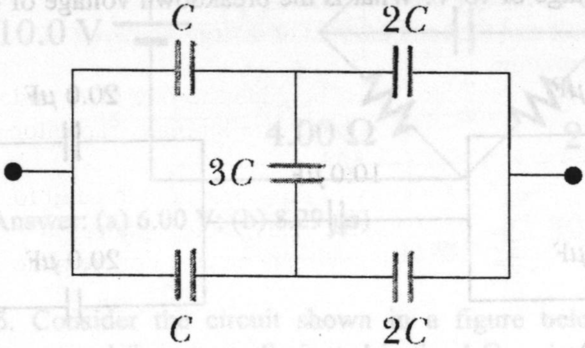
59. Evaluate the equivalent capacitance of the configuration shown in the figure below. All the capacitors are identical, and each has capacitance C.



(Answer: 1.83C)

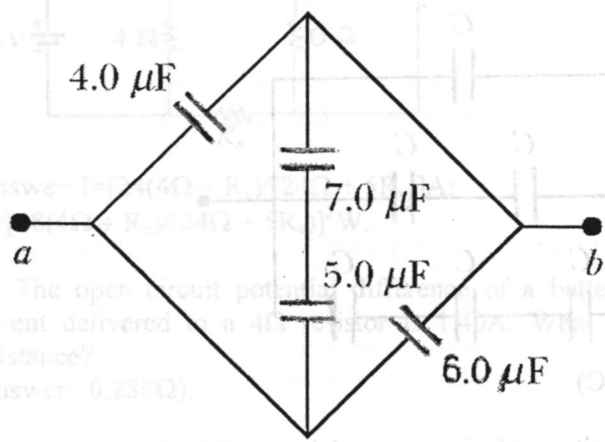
60. Two capacitors when connected in parallel give an equivalent capacitance of 9 pF and an equivalent capacitance of 2 pF when connected in series. What is the capacitance of each capacitor?
(6.00 pF and 3.00 pF)

61. Determine the equivalent capacitance of the combination shown in Figure below. (*Suggestion:* Consider the symmetry involved.)



(Answer: 1.33 C)

62. Find the equivalent capacitance between points a and b in the combination of capacitors:



(Answer: 12.9 μF)

63. Two parallel-plate vacuum capacitors have areas A_1 and A_2 and equal plate spacing d. Show that when the capacitors are connected in parallel, the equivalent capacitance is the same as for a single capacitor with plate area $A_1 + A_2$ and spacing d.
(Hint: *use the formula for the parallel-plate capacitors.*)

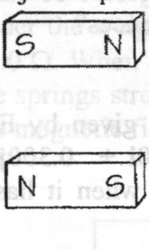
64. (a) How many excess electrons must be added to one plate and removed from the other to give a 5.00nF parallel-plate capacitor 25.0J of stored energy?
(b) How could you modify the geometry of this capacitors to get it to store 50.0J of energy without changing the charges of its plates?
(Answer: (a) $3.12 \cdot 10^{15}$ electrons; (b) halve plate area or double plate separation).

Classical Physics
Electricity
Individual Home Works III

Variants	Questions		Problems			
I	3.1	3.10	3.01	3.14	3.29	3.45
II	3.3	3.12	3.02	3.15	3.30	3.46
III	3.5	3.14	3.03	3.16	3.31	3.47
IV	3.7	3.16	3.04	3.17	3.32	3.48
V	3.9	3.18	3.05	3.18	3.33	3.49
VI	3.11	3.20	3.06	3.19	3.34	3.50
VII	3.13	3.2	3.07	3.20	3.35	3.51
VIII	3.15	3.4	3.08	3.21	3.36	3.52
IX	3.17	3.6	3.09	3.22	3.37	3.53
X	3.19	3.8	3.10	3.23	3.38	3.54
XI	3.2	3.11	3.11	3.24	3.39	3.55
XII	3.4	3.13	3.12	3.25	3.40	3.56
XIII	3.6	3.15	3.13	3.26	3.41	3.57
XIV	3.8	3.17	3.14	3.27	3.42	3.58
XV	3.10	3.19	3.15	3.28	3.43	3.59
XVI	3.12	3.1	3.16	3.29	3.44	3.60
XVII	3.14	3.3	3.17	3.30	3.45	3.61
XVIII	3.16	3.5	3.18	3.31	3.46	3.62
XIX	3.18	3.7	3.19	3.32	3.47	3.63
XX	3.21	3.9	3.20	3.33	3.48	3.64

4. Magnetism
Questions

1. A wire carrying a current is electrically neutral, yet a magnetic field acts on it. Why?
2. Is it possible for an electron to move in a straight line through a magnetic field? If so, how?
3. Can a magnetic pole repel or attract static electric charges?
4. Suppose you move a compass needle near a straight wire that carries a current. Describe how the compass needle reacts when the compass is moved slowly in a circle centered on the wire and perpendicular to it.
5. When two bar magnets are placed side by side with the opposed adjacent poles (see the picture below), will they attract or repel?



6. Heating magnets or passing electric currents through them will cause a reduction in field strength. Explain.
7. A proton passes through a region of space without being deflected. Can we say positively that no magnetic field exist in that region? Discuss.
8. The equal and opposite forces acting on a current loop in a magnetic field form what is called a couple. Show that the resultant torque on such a couple is the product of one of the forces and the perpendicular distance between their lines of action.
9. Explain the torque exerted on a bar magnet suspended in a magnetic field without referring to magnetic poles. Discuss, from an atomic standpoint, how the observed torque may arise from the same cause as the torque on a current loop.
10. Discuss the various factors that influence the magnitude of an induced emf in a length of wire moving in a magnetic field.

11. When the electric motor in a plant is starting, a worker notices that the lights are momentarily dimmed. Explain.

Problems

Motion of Charged Particles in a Magnetic Field

1. A proton moving at $4\cdot10^6$ m/s through a magnetic field of 1.70 T experiences a magnetic force of magnitude $8.2\cdot10^{-13}$ N. What is the angle between the proton's velocity and the field?
(Answer: 48.9° or 131°)

2. A proton moves with a velocity of v = (2**i** - 4**j** + **k**) m/s in a region in which the magnetic field is B = (**i** + 2**j** - 3**k**)T. What is the magnitude of the magnetic force this charge experiences?
(Answer: 2.335 aN)

3. A proton moves through a uniform electric field given by E = 50.0**j** V/m and a uniform magnetic field B = (0.200**i** + 0.300**j** + 0.400**k**)T. Determine the acceleration of the proton when it has a velocity v = 200**i** m/s.
(Answer: -2.87**j** + 5.75**k**) Gm/s^2

4. The magnetic field of the Earth at a certain location is directed vertically downward and has a magnitude of 50 μT. A proton is moving horizontally toward the west in this field with a speed of $6.2\cdot10^6$ m/s. (a) What are the direction and magnitude of the magnetic force
the field exerts on this charge?
(b) What is the radius of the circular arc followed by this proton?
(Answer: (a) 49.6 aN south (b) 1.29 km)

5. A positive charge q = $3.2\cdot10^{-19}$ C moves with a velocity **v** =(2**i** +3**j** - **k**) m/s through a region where both a uniform magnetic field and a uniform electric field exist.
(a) Calculate the total force on the moving charge (in unit-vector notation), taking **B** = (2**i** + 4**j** + **k**) T and E = (4**i** - **j** - 2**k**) V/m.

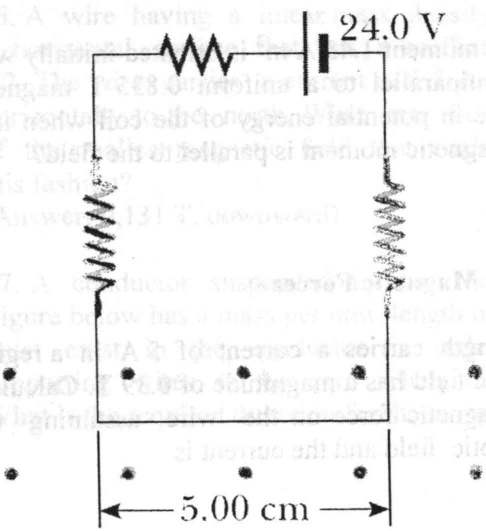
(b) What angle does the force vector make with the positive x axis?

(Answer: (a) ($3.52\mathbf{i} - 1.60\mathbf{j}$) aN (b) 24.4°)

6. One electron collides elastically with a second electron initially at rest. After the collision, the radii of their trajectories are 1 cm and 2.4 cm. The trajectories are perpendicular to a uniform magnetic field of magnitude 0.044 T. Determine the energy (in keV) of the incident electron.

(Answer: 115 keV)

7. The circuit in a figure below consists of wires at the top and bottom and identical metal springs in the left and right sides. The upper portion of the circuit is fixed. The wire at the bottom has a mass of 10.0 g and is 5.00 cm long. The springs stretch 0.500 cm under the weight of the wire and the circuit has a total resistance of 12.0 Ω. When a magnetic field is turned on, directed out of the page, the springs stretch an additional 0.300 cm. What is the magnitude of the magnetic field?



(Answer: 0.588 T)

8. A 150-g ball containing $4.00\cdot10^{8}$ excess electrons is dropped into a 125-m vertical shaft. At the bottom of the shaft, the ball suddenly enters a uniform horizontal magnetic field that has magnitude 0.250T and direction from east to west. If air resistance is negligibly small, find the magnitude and direction of the force that this magnetic field exerts on the ball just as it enters the field
(Answer: $7.93\cdot10^{-10}$ N, south).

9. An electron in the beam of a TV picture tube is accelerated by a potential difference of 2.00kV. Then it passes trough a region of transverse magnetic field, where it moves in a circular arc with radius 0.180m. What is the magnitude of the field?
(Answer: $8.38\cdot10^{-4}$T).

10. A horizontal rod 0.200m long is mounted on a balance and carries a current. At the location of the rod a uniform horizontal magnetic field has magnitude 0.067T and direction perpendicular to the rod. The magnetic force on the rod is measured by the balance and is found to be 0.13N. What is the current?
(Answer: 9.7A).

11. A coil with magnetic moment 1.45 $A\cdot m^{2}$ is oriented initially with its magnetic moment antiparallel to a uniform 0.835-T magnetic field. What is the change in potential energy of the coil when it is rotated 180^{0} so that its magnetic moment is parallel to the field?
(Answer: -2.42J).

Magnetic Forces

12. A wire 2.8 m in length carries a current of 5 A in a region where a uniform magnetic field has a magnitude of 0.39 T. Calculate the magnitude of the magnetic force on the wire assuming the angle between the magnetic field and the current is
(a) 60°,
(b) 90°,
(c) 120°.
(Answer: (a) 4.73 N, (b) 5.46 N, (c) 4.73 N)

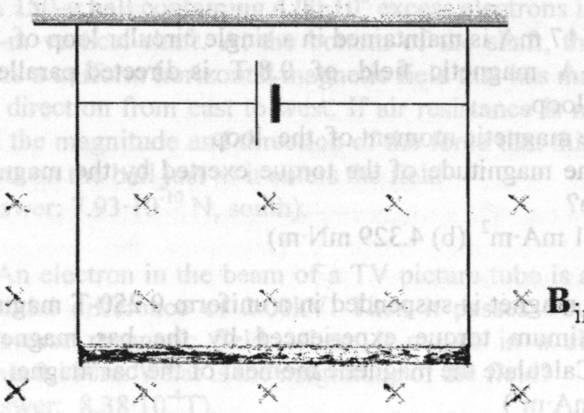
13. A current of 17 mA is maintained in a single circular loop of 2 m circumference. A magnetic field of 0.8 T is directed parallel to the plane of the loop.
(a) Calculate the magnetic moment of the loop.
(b) What is the magnitude of the torque exerted by the magnetic field on the loop?
(Answer: (a)5.41 mA·m^2 ,(b) 4.329 mN·m)

14. A small bar magnet is suspended in a uniform 0.250-T magnetic field. The maximum torque experienced by the bar magnet is $4.60 \cdot 10^{-3}$ N·m. Calculate the magnetic moment of the bar magnet.
(Answer: 18.4 mA·m^2)

15. A 0.2 kg metal rod carrying a current of 10 A glides on two horizontal rails 0.5 m apart. What vertical magnetic field is required to keep the rod moving at a constant speed if the coefficient of kinetic friction between the rod and rails is 0.1?
(Answer: 0,392 T)

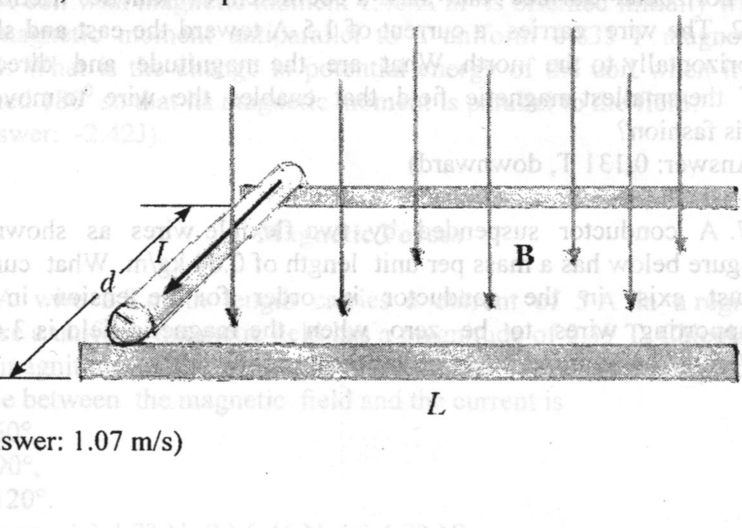
16. A wire having a linear mass density of 1 g/cm is placed on a horizontal surface that has a coefficient of kinetic friction of 0.2. The wire carries a current of 1.5 A toward the east and slides horizontally to the north. What are the magnitude and direction of the smallest magnetic field that enables the wire to move in this fashion?
(Answer: 0,131 T, downward)

17. A conductor suspended by two flexible wires as shown in Figure below has a mass per unit length of 0.04 kg/m. What current must exist in the conductor in order for the tension in the supporting wires to be zero when the magnetic field is 3.6 T? What is the required direction for the current?



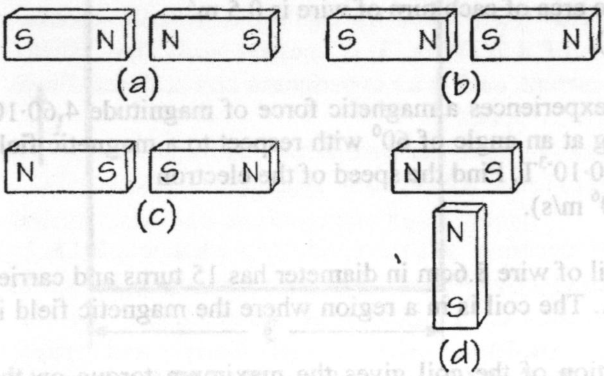
(Answer: 0,109 A, rightwards)

18. A rod of mass 720 g and radius 6 cm rests on two parallel rails (see a figure below) that are 12 cm apart and 45 cm long. The rod carries a current of 48 A (in the direction shown) and rolls along the rails without slipping. A uniform magnetic field of 240 mT is directed perpendicular to the rod and the rails. If it starts from rest, what is the speed of the rod as it leaves the rails?

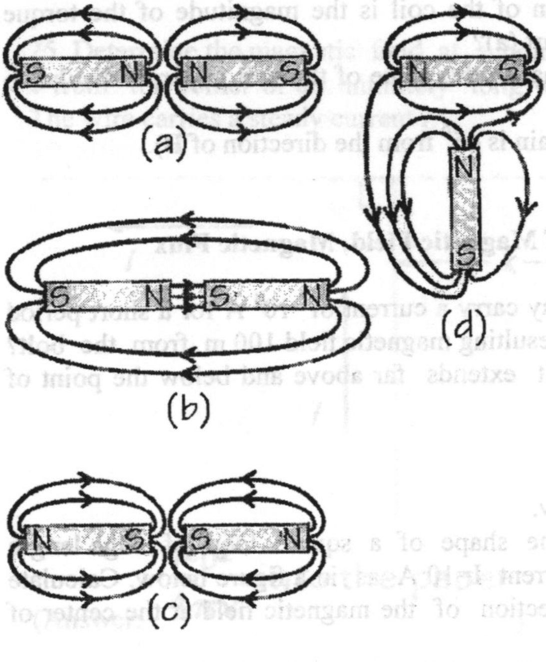


(Answer: 1.07 m/s)

19. Sketch the magnetic fields for the arrangements of bar magnets.



(Answer:



)

20. The axis of a solenoid that has 750 turns of wire makes an angle of 34^0 with a 5-mT field. What is the current if the torque is 4.0N·m at that angle? The area of each turn of wire is 0.5 m^2
(Answer: 7.63A).

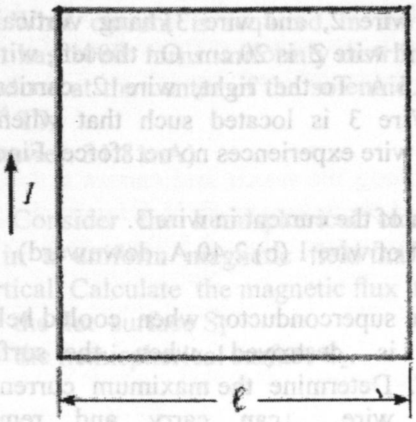
21. An electron experiences a magnetic force of magnitude $4.60 \cdot 10^{-15}$N when moving at an angle of 60^0 with respect to a magnetic field of magnitude $3.50 \cdot 10^{-3}$T. Find the speed of the electron
(Answer: $9.47 \cdot 10^6$ m/s).

22. A circular coil of wire 8.6cm in diameter has 15 turns and carries a current of 2.7A. The coil is in a region where the magnetic field is 0.56T.
(a) What orientation of the coil gives the maximum torque on the coil, and what is the maximum torque?
(b) for what orientation of the coil is the magnitude of the torque 71% of that found in part (a)?
(Answer: (a) the normal to the plane of the coil is perpendicular to **B**; 0.13N·m;
(b) the normal to the plain is 45^0 from the direction of **B**).

Sources of Magnetic Field, Magnetic Flux

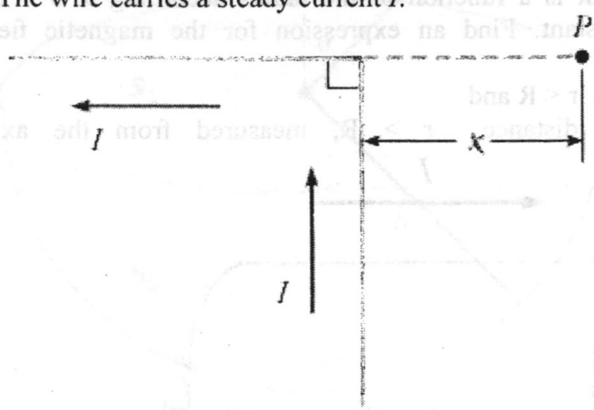
23. A lightning bolt may carry a current of 10^4 A for a short period of time. What is the resulting magnetic field 100 m from the bolt? Suppose that the bolt extends far above and below the point of observation.
(Answer: $2 \cdot 10^{-5}$ T)

24. See the figure below.
(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 a figure 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?



(Answer: (a) 28.3 μT into the paper (b) 24.7 μT into the paper)

25. 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*.

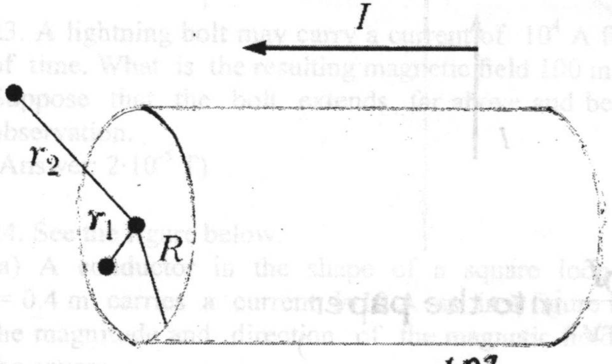


(Answer: $\dfrac{\mu_0 I}{4\pi x}$ into the paper)

26. Three long wires (wire 1, wire 2, and wire 3) hang vertically. The distance between wire 1 and wire 2 is 20 cm. On the left, wire 1 carries an upward current of 1.5 A. To the right, wire 2 carries a downward current of 4 A. Wire 3 is located such that when it carries a certain current, each wire experiences no net force. Find
(a) the position of wire 3, and
(b) the magnitude and direction of the current in wire 3.
(Answer: (a) 12.0 cm to the left of wire 1 (b) 2.40 A, downward)

27. Niobium metal becomes a superconductor when cooled below 9 K. Its superconductivity is destroyed when the surface magnetic field exceeds 0.1 T. Determine the maximum current a 2 mm diameter niobium wire can carry and remain superconducting, in the absence of any external magnetic field.
(Answer: 1 kA)

28. A long cylindrical conductor of radius R carries a current I. The current density J , however, is not uniform over the cross section of the conductor but is a function of the radius according to J = br, where b is a constant. Find an expression for the magnetic field B
(a) at a distance r < R and
(b) at a distance r > R, measured from the axis.



(Answer: (a) $\frac{1}{3}\mu_0 b r_1^2$ (b) $\frac{\mu_0 b R^3}{3r_2}$)

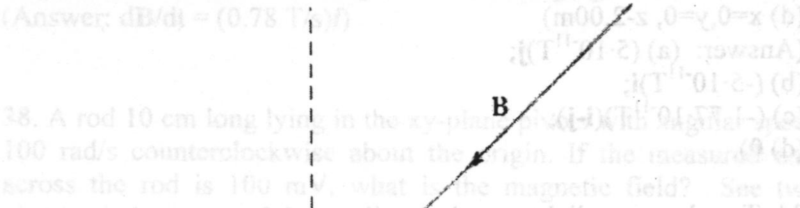
29. What current is required in the windings of a long solenoid that has 1000 turns uniformly distributed over a length of 0.4 m, to produce at the center of the solenoid a magnetic field of magnitude 10^{-4} T?

(Answer: 31.8 mA)

30. Consider the hemispherical closed surface. The hemisphere is in a uniform magnetic field that makes an angle Θ with the vertical. Calculate the magnetic flux through

(a) the flat surface S_1

(b) the hemispherical surface S_2.



(Answer: (a) $\pi r^2 B\sin(\Theta)$, (b) $-\pi r^2 B\sin(\Theta)$)

31. A 0.1 A current is charging a capacitor that has square plates 5 cm on each side. The plate separation is 4 mm. Find

(a) the time rate of change of electric flux between the plates and

(b) the displacement current between the plates.

(Answer: (a) 11.3 GV·m/s, (b) 0.100 A)

32. Calculate the magnetic flux density required to give a coil of 100 turns a torque of 0.5N·m when its plane is parallel to the field. The area of each turn is $84cm^2$, and the current is 9.0A
(Answer: 66.1mT).

33. A long straight wire lies along the z-axis and carries a 4.00-A current in the +z-direction. Find the magnetic field (magnitude and direction) produced at the following points by a 0.500mm segment of the wire centered at the origin:
(a) x=2.00m, y=0, z=0;
(b) x=0, y=2.00m, z= 0;
(c) x=2.00m, y=2.00m, z=0;
(d) x=0,y=0, z-2.00m)
(Answer: (a) $(5\cdot10^{-11}T)$**j**;
(b) $(-5\cdot10^{-11}T)$**i**;
(c) $(-1.77\cdot10^{-11}T)$(**i**-**j**);
(d) 0).

34. Two long parallel transmission lines, 40.0cm apart, carry 25.0-A and 75.0-A currents. Find all locations where the net magnetic field of the two wires is zero if these currents are in
(a) the same direction;
(b) the opposite direction
(Answer: (a) between the wires, 30.0cm from wire carrying 75.0A;
(b) 20.0cm from the wire carrying 25.0A and 60.0cm from the wire carrying 75.0A).

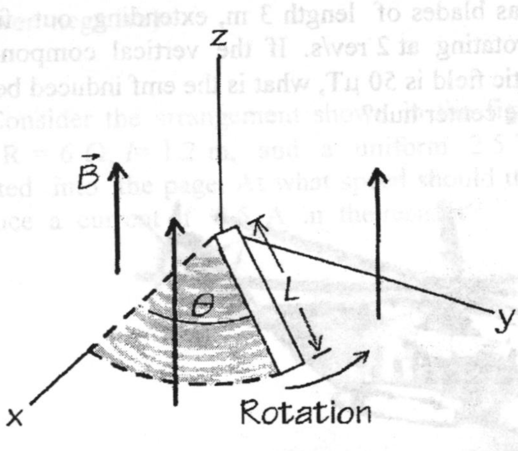
35. Two long parallel wires are separated by a distance of 2.50cm. The force per unit length that each wire exerts on the other is $4.00\cdot10^{-5}$ N/m, and the wires repel each other. The current in one wire is 0.600A.
(a) What is the current in the second wire?
(b) Are the two currents in the same direction or in opposite direction?
(Answer: (a) 8.33A;
(b) opposite).

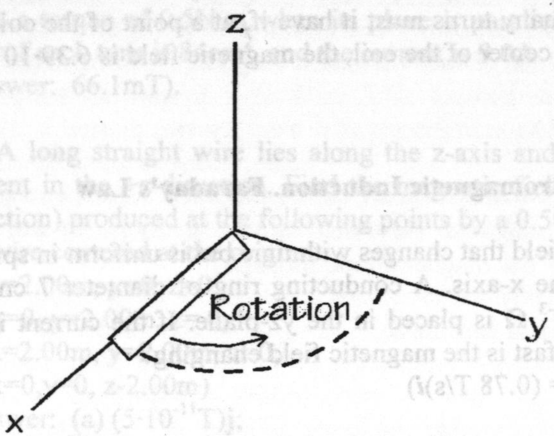
36. A closely wound coil has a radius of 6.00cm and carries a current of 2.50A. How many turns must it have if, at a point of the coil axis 6.00cm from the center of the coil, the magnetic field is $6.39 \cdot 10^{-4}$T? (Answer: 69).

Electromagnetic Induction. Faraday's Law

37. A magnetic field that changes with time but is uniform in space is directed along the x-axis. A conducting ring of diameter 7 cm and resistance $1.5 \cdot 10^{-3}$ Ω is placed in the yz-plane. If the current in the ring is 2 A, how fast is the magnetic field changing?
(Answer: $d\mathbf{B}/dt = (0.78\ T/s)\boldsymbol{i}$)

38. A rod 10 cm long lying in the xy-plane pivots with angular speed 100 rad/s counterclockwise about the origin. If the measured emf across the rod is 100 mV, what is the magnetic field? See two pictures below.



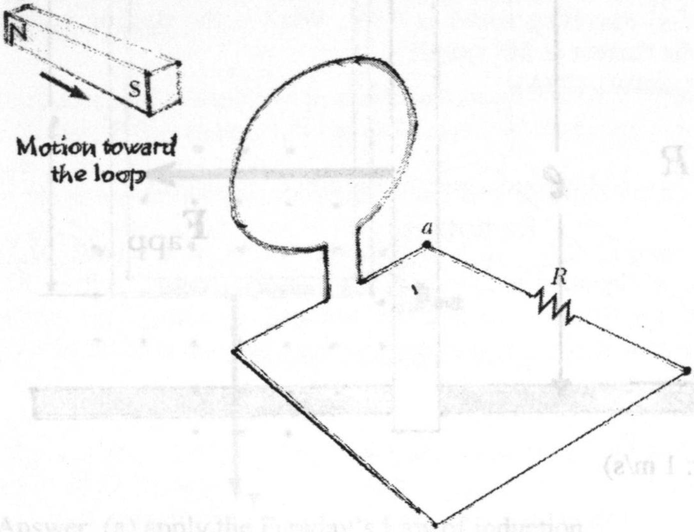


(Answer: 0.2 T)

39. A helicopter has blades of length 3 m, extending out from a central hub and rotating at 2 rev/s. If the vertical component of the Earth's magnetic field is 50 μT, what is the emf induced between the blade tip and the center hub?

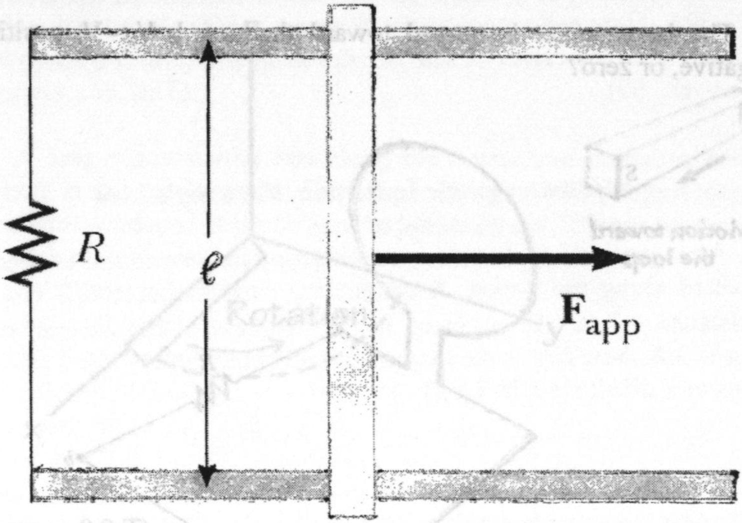
(Answer: 2.83 mV)

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



(Answer: negative)

41. Consider the arrangement shown in the figure below. Assume that $R = 6\ \Omega$, $l = 1.2$ m, and a uniform 2.5 T magnetic field is directed into the page. At what speed should the bar be moved to produce a current of 0.5 A in the resistor?

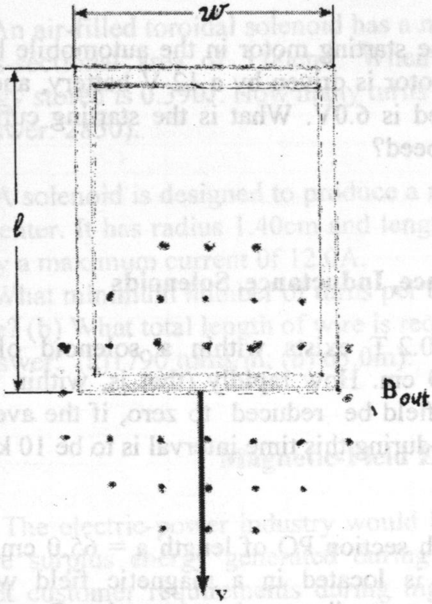


(Answer: 1 m/s)

42. A conducting rectangular loop of mass M, resistance R, and dimensions ***w*** by ***l*** falls from rest into a magnetic field ***B*** as shown in the figure below. During the time interval before the top edge of the loop reaches the field, the loop approaches a terminal speed V_T.
(a) Show that

$$v_T = \frac{MgR}{B^2 w^2}$$

(b) Why is V_T proportional to R?
(c) Why is it inversely proportional to B^2?



(Answer: (a) apply the Faraday's Law of induction.
(b) Larger R makes current smaller, so the loop must travel faster to maintain equality of magnetic force and weight.
(c) The magnetic force is proportional to the product of field and current, while the current is itself proportional to field. If B becomes two times smaller, the speed must become four times larger to compensate.)

43. A coil of 300 turns moving perpendicular to the flux in uniform magnetic field experiences a flux linkage of 0.3mWb in 0.002s. What is the induced emf?
(Answer: -34.5V).

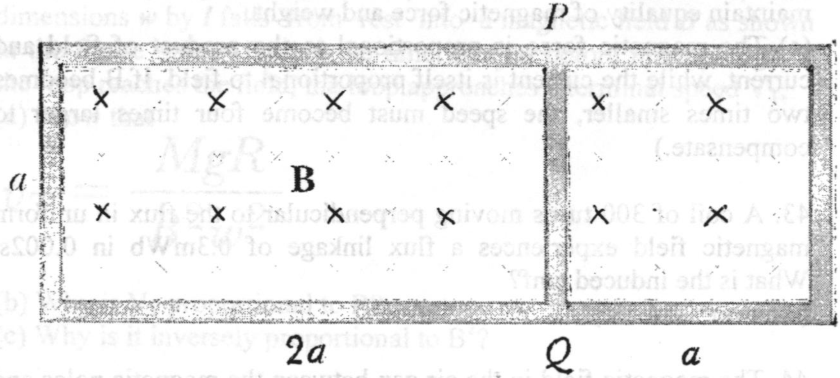
44. The magnetic field in the air gap between the magnetic poles and the armature of an electric generator has a flux density of 0.7T. The length of the wires on the armature is 0.5m. How fast must these wires move to generate a maximum emf of 1.0V in each armature wire?
(Answer: 2.86m/s).

45. The armature coil of the starting motor in the automobile has a resistance of 0.05Ω. The motor is driven by a 12-V battery, and the back emf at operating speed is 6.0V. What is the starting current? What is the current at full speed?
(Answer: 240A; 120A).

Self-inductance, Inductance, Solenoids

46. A magnetic field of 0.2 T exists within a solenoid of 500 turns and a diameter of 10 cm. How rapidly (that is, within what period of time) must the field be reduced to zero, if the average induced emf within the coil during this time interval is to be 10 kV?
(Answer: 78,539 μs)

47. Find the current through section PQ of length a = 65.0 cm in a figure below. The circuit is located in a magnetic field whose magnitude varies with time according to the expression B = (1.00 mT/s)t. Assume the resistance per length of the wire is 0.100 W/m.



(Answer: 283 μA upward)

48. An air-filled toroidal solenoid has a mean radius of 15.0cm and a cross-sectional area of 5.00cm^2. When the current is 12.0A, the energy stored is 0.390J. How many turns does the winding have?
(Answer: 2850).

49. A solenoid is designed to produce a magnetic field of 0.0270T at its center. It has radius 1.40cm and length 40.0cm, and the wire can carry a maximum current Of 12.0A.
(a) What minimum number of turns per unit length must the solenoid have? (b) What total length of wire is required?
(Answer: (a)1790 turns/m; (b) 63.0m).

Magnetic-Field Energy

50. The electric-power industry would like to find efficient ways to store surplus energy generated during low-demand hours to help meet customer requirements during high-demand hours. Perhaps a large inductor can be used. What inductance would be needed to store 1.00 kWh of energy in a coil carrying a 200-A current?
(Answer: 180H).

51. In a proton accelerator used in elementary particle experiments, the trajectories of protons are controlled by bending magnets that produce a magnetic field of 6.6T. What is the energy density in this field in the vacuum between the poles of such a magnet?
(Answer: $1.73 \cdot 10^7$ J/m^3).

Classical Physics
Magnetism
Individual Home Works IV

Variants	Questions		Problems			
I	4.01	4.07	4.01	4.13	4.26	4.41
II	4.02	4.08	4.02	4.14	4.27	4.42
III	4.03	4.09	4.03	4.15	4.28	4.43
IV	4.04	4.10	4.04	4.16	4.29	4.44
V	4.05	4.11	4.05	4.17	4.30	4.45
VI	4.06	4.01	4.06	4.18	4.31	4.46
VII	4.07	4.02	4.07	4.19	4.32	4.47
VIII	4.08	4.03	4.08	4.20	4.33	4.48
IX	4.09	4.04	4.09	4.21	4.34	4.49
X	4.10	4.05	4.10	4.22	4.35	4.50
XI	4.11	4.06	4.11	4.23	4.36	4.51
XII	4.03	4.07	4.12	4.24	4.37	4.01
XIII	4.04	4.08	4.13	4.25	4.38	4.02
XIV	4.05	4.09	4.14	4.26	4.39	4.03
XV	4.06	4.10	4.15	4.27	4.40	4.04
XVI	4.07	4.11	4.16	4.28	4.41	4.05
XVII	4.08	4.01	4.17	4.29	4.42	4.06
XVIII	4.09	4.02	4.18	4.30	4.43	4.07
XIX	4.10	4.03	4.19	4.31	4.44	4.08
XX	4.11	4.04	4.20	4.32	4.45	4.09

Appendix

Some units

1 mi	one mile	= 1609 m
1 h	one hour	= 3600 s
1 dm	one decimeter	=0.1 m
1 Btu	British thermal unit	= 1055 J
1 cal	calorie	= 4.186 J

Some constants

The π-constant	π	3.1415926
Speed of light	c	$2.9979 \cdot 10^{8}$ m/s^2
Avogadro's number	N_a	$6.022 \cdot 10^{23}$ 1/mol
Boltzmann's constant	k	$1.38 \cdot 10^{-23}$ J/K
Electron charge	e	$1.602 \cdot 10^{-19}$ C
Coulomb constant	k	$8.988 \cdot 10^{9}$ N*m^2
Gas constant	R	8.31446 J/(K·mol)
Electric permeability of vacuum	ε_0	8.8541878 pF/m
Magnetic permeability of vacuum	μ_0	$4\pi \cdot 10^{-7}$ H/m
Planck constant	h	$6.62606 \cdot 10^{-34}$ J·s
Reduced Plank constant	$\hbar$	$1.054\ 571 \cdot 10^{-34}$ J·s
Gravitational constant	G	$6.673 \cdot 10^{-11}$Nm^2/kg^2

Decimal Prefixes and Multiples, Powers of Ten

Multiple	Prefix	Symbol	Common Name
$(10^{100})^{100}$	anton	A	antonplex
$(10^{10})^{100}$	-	-	googolplex
10^{100}	-	-	googol
10^{24}	yotta	Y	heptillion
10^{21}	zetta	Z	hexillion
10^{18}	exa	E	quintillion
10^{15}	peta	P	quadrillion
10^{12}	tera	T	trillion
10^{9}	giga	G	billion
10^{6}	mega	M	million
10^{3}	kilo	k	thousand
10^{2}	hecto	h	hundred
10^{1}	deca	da	ten
10^{-1}	deci	d	tenth
10^{-2}	centi	c	hundreth
10^{-3}	milli	m	thousandth
10^{-6}	micro	µ	millionth
10^{-9}	nano	n	billionth
10^{-12}	pico	p	trillionth
10^{-15}	femto	f	quadrillionth
10^{-18}	atto	a	quintillionth
10^{-21}	zepto	z	hexillionth
10^{-24}	yocto	y	heptillionth

Kazakh-British Technical University

Faculty of Energy and Oil and Gas Industry
Engineering and Physics Department

«Approved by»
Dean of FOGI
________ Bekmuhametova Z.A.
(____)_____ ____ 2011.

Syllabus

Discipline:	Classical Physics (Physics I)
Faculty	FOGI, FIT
Year	1 year
Number of credits:	3 (1/1/1) (Lect/Lab/Sem)
Terms:	Autumn semester of 2011-2012 academic year.
Lecturer:	Voronkov Vladimir Vassilyevich

Prerequisites: Calculus 1-2.

Brief Description: Classical Physics (Physics I) is the first part of the 2-semester course including the basic topics of General Physics. During this semester the main focus will be on laws of Mechanics, properties of fluids, the main principles of Thermodynamics, Electricity and Magnetism. The course reflects current state of modern physics and combines both macroscopic and microscopic approaches.

The objective of the course for the student is to achieve good understanding of basic concepts and to be able to apply these concepts to a variety of physical situations. Students will acquire skills in scientific methods, critical reasoning and problem solving. It is important for students to develop skills for experimental researches and computer simulations of physical phenomena.

Curriculum plan

week	Classroom				Tasks type and deadline	
	Topic	Lect.	Lab.	Sem	References	
	Module 1. Mechanics					
1	Introduction. Mechanics. Kinematics.Straight-line motion. Projectile motion. Uniform circular motion. Lab: Introduction to lab session.	1	1	1	1. Ch. 2,3 2. Lecture 1 3. Ch. 1 5. Ch. 1	Assignment of IHW 1
2	Forces in mechanics. Dynamics. Newton's laws of motion and their application. Lab 1. Uncertainties of the measurements and error propagation	1	1	1	1. Ch. 4,5 2. Lecture 2 3. Ch. 2	

					5. Ch. 2	
3	Work, energy and power. Conservation of energy. Impulse and momentum. Collisions. Lab 2. Determination of the acceleration of gravity using the Atwood machine	1	1	1	1. Ch. 6-8 2. Lecture 3 3. Ch. 3,4 5. Ch. 3	Defense of IHW 1. Assignment of IHW 2
4	Rotation of rigid bodies. Angular momentum and torque. Properties of fluids. Lab 3. Determination the speed of a bullet shot from a gun using ballistic method	1	1	1	1. Ch.9, 10,16 2. Lecture 4 3. Ch. 5,9 5. Ch. 4,6 6. Ch. 16	
Module 2. Molecular Physics and Thermodynamics						
5	Molecular-kinetic Theory of ideal gases. Molecular bases of thermal physics. Collisions and transport phenomena. Lab 4. Binomial probability distribution	1	1	1	1. Ch. 17 2. Lecture 5 3. Ch. 10,11 5. Ch. 8	Quiz 1
6	Heat flow and the first law of thermodynamics. Kind of thermodynamic process. Adiabatic processes. Lab 5. Determination of the liquid viscosity by Stokes' law	1	1	1	1. Ch. 18 2. Lecture 6 3. Ch. 11,12 5. Ch.9	Defense of IHW 2 Assignment of IHW3

7	The second law of thermodynamics. Entropy.The Carnot cycle. The engines. Real gases. Fluids and solids.	1	1	1	1. Ch. 19, 20 2. Lecture 7 3. Ch. 12 5. Ch.9,10	
8	**Midterm exam**					
	Module 3. Electricity					
8	Electric charge. Electric field. Gauss' law. Electric potential. Applications of Gauss' law.	1	1	1	1. Ch. 21-24 2. Lecture 8 4. Ch. 1 5. Ch. 11	
9	Insulators and conductors in electric field. Capacitance and dielectrics. Current, resistance and electromotive Force. Lab 6. Determination of specific (latent) heat of crystallization (fusion) and entropy change for Rose's alloy	1	1	1	1. Ch. 25 2. Lecture 9 4. Ch. 2-5 5. Ch. 11	
10	Currents in materials. Direct current circuits. Battery, resistors, Kirchhoff rules. Lab 7. Investigation of electrostatic fields.	1	1	1	1. Ch. 26,27 2. Lect 10 4. Ch. 5 5. Ch. 12	Defense of IHW 3 Assignment of IHW4
11	Currents in Metals, Vacuum and Gases. Emission Phenomena. Lab 8. Determination of resistance and resistivity.	1	1	1	1. Ch.27 2. Lect. 11 4. Ch. 11,12	

					5. Ch. 13	
Module 4. Magnetism						
12	The effects of magnetic fields. The production and properties of magnetic fields. Lab 9. Study of Hall effect in semiconductors.	1	1	1	1. Ch.28, 29 2. Lect. 12 4. Ch. 7 5. Ch. 14	Quiz 2
13	Motion of charged particles in a magnetic field. Forces and torques in a magnetic field. The Hall effect. Lab 10. Study of magnetic field on the axis of a cylindrical coil	1	1	1	1. Ch. 28 2. Lect. 13 4. Ch. 7,10,11 5. Ch. 14	
14	Electromagnetic induction. Faraday's law. Inductance. Self-inductance. Transformers.	1	1	1	1. Ch. 30,32 2. Lect. 14 4. Ch.8 5. Ch.15	Defen-se of IHW 4
15	Magnetism and matter. Maxwell's equations and electromagnetic waves.	1	1	1	1. Ch 31, 34 2. Lect. 15 4. Ch. 7,9 5. Ch. 16,17	**End-term**
16-19	**Final exam**					

Recommended Textbooks (main):

1. P. Fishbane, S. Gasiorowicz, S. Thornton. Physics for Scientists and Engineers (extended version) Publisher: Prentice Hall, Inc.,2005
2. Lectures on Physics. Summary. Compiled by F.F. Umarov/Almaty:KBTU, 2008.
3. Савельев И.В. Курс общей физики. Т.1 М.:Наука. 2000.
4. Савельев И.В. Курс общей физики. Т.2 М.:Наука. 2000.
5. Трофимова Т.И. Курс физики. М.:Высшая школа. 2001.
6. A. Serway, J. Jewett. Physics for Scientists and Engineers, 6th Edition Thomson Brooks/Cole 2004.

Additional textbooks:

7. Детлаф А.А., Яворский Б.М. Курс физики.- М.: Высшая школа. 2001.
8. Волькенштейн В.С. Сб. задач по общему курсу физики. – М.: Наука. 2003.
9. Огурцов А.Н. Лекции по физике (1 - 4 части), 2002.
10. Umarov F.F., Koshkimbaeva A.Sh., Slyunayeva N.V. «Physics I. Lab manual. Mechanics, Molecular Physics and Thermodynamics, Electricity and Magnetism», Almaty: KBTU, 2009.
11. Механика, молекулярная физики и термодинамика, электричество и магнетизм. Задания к практическим занятиям. Под общей редакцией Лагутиной Ж.П.

Learning outcomes: After studying this unit the student should be able:

- to achieve a good understanding of basic concepts and to be able to apply these concepts to a variety of physical situations
- to acquire skills in scientific methods, critical reasoning and problem solving

Individual Home Works are assigned regularly. It is important to work over physics problems to obtain a good understanding of the

Material covered. You are required to hand over all the homework problems. It is important that you show the work in an organized manner clearly showing the final answer with appropriate units. Each home work set is 3 points. The mark is given only after defense of the IHW which consists of detailed explanation of solution of all submitted problems.

Labs: General Physics-1 accompanies a weekly laboratory. There will be 14 lab classes available. The total points earned in labs accounts for 20 points. Experiments are based on the material covered in the lectures. The handouts for the labs are available on the course website.

Quizzes: There are two quizzes, their total weight is 8 points. Students are supposed to prepare to quizzes using special preparation files posted on the Intranet. This preparation will help the students to obtain good marks.

Exams: A Midterm, Endterm and Final exams will be given. The exams are closed book and notes. Students are expected to know basic expressions and equations used in Physics. The exams will consist of multiple choice tests, conceptual questions and problems similar to suggested those in homeworks, and discussed in lectures. There are no make up exams. The final exam will be held on the dates given for each section. Students are supposed to prepare to these Exams using special preparation files posted on the Intranet beforehand. This preparation will significantly help the students to obtain good marks.

Assessment methods: The final grade will depend on the student's performance in all areas of the course and will be weighted as follows:

Work	Score	Pass Time
Individual Home Works 1 and 2 (IHW 1 and 2)	$3 + 3 = 6$	Weeks 3 and 6
Labs	$2 \cdot 5 = 10$	Weeks 3 – 8
Quiz 1	4	Week 5
Midterm Exam	10	Week 8
Total for the first attestation	**30**	
Individual Home Works 3 and 4 (IHW 3 and 4)	$3 + 3 = 6$	Weeks 10 and 14
Labs	$2 \cdot 5 = 10$	Weeks 11 - 15
Quiz 2	4	Week 12
Endterm	10	Week 15
Total for the second attestation	**30**	
Total for two attestations	**60**	
Final Exam	**40**	Weeks 16-18
Total for the discipline	**100**	

Students receive the general total grade which is a cumulative indicator of their work during the semester. There also are possible additional bonus points (no more than 5 for each attestation) for other activities, such as participation in the Physics Olympiads or Scientific Conferences and etc.

Grading policy:

- If a student gets less than 30 points for both attestations then the student gets FAIL for the discipline.
- If a student gets less than 20 points for the Final Exam then the student gets FAIL for the discipline.
- If a student does not appear at the Final Exam then the student gets FAIL for the discipline (even if the student's score for both attestations is above 50 points).
- If a student misses some lessons or the Final Exam in the case of illness then the student must give the doctor's certificate to the KBTU medical centre during three days after the last date of the

certificate. And only if the medical centre approves the doctor's certificate then the student is considered to have reasonable excuse in missing the lesson or the Final Exam.

Schedule date of tasks

№	Type of evaluation	Week																Total
		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16-17	
1	Quizzes					*							*					8
2	SIS: homework			*			*				*				*			12
3	Labs		*	*	*	*	*			*	*	*	*	*				20
4	Mid-term exam								*									10
5	End-term exam															*		10
6	Final exam																*	40
	Total																	**100**

The final grade will be calculated according to the evaluation system accepted in KBTU:

Grade (letter)	GPA	Points , %	Descriptors
A	4	95-100	A superior / outstanding performance
A-	3,67	90-94	"excellent"
B+	3,33	85-89	"very good"
B	3	80-84	A good / above average performance
B-	2,67	75-79	
C+	2,33	70-74	
C	2	65-69	A generally satisfactory, intellectually adequate performance
C-	1,67	60-64	
D+	1,33	55-59	Poor
D	1	50-54	A barely satisfactory performance
F	0	1-49	"Failure" An unacceptable performance
I	0	0	"incomplete"
W	0	0	"Withdrawal"
AW	0	0	"administrative withdrawal"
AU	0	0	"course audits"
P/NP		65-100	Pass / No Pass

Attendance: Students are expected to attend at least 80% of lectures and seminars and to participate in classroom problem solving. Students should consult with the instructor when an unavoidable absence due to an emergency or illness occurs.

Note: cellular phones must be silenced during lecture and laboratory attendance.

Was considered at session of Engineering-Physics Department, record № 1 "17" August 2011

References

1. Paul M. Fishbane, Stephen G. Gasiorowicz, Stephen T. Thornton. Physics for Scientists and Engineers with Modern Physics. Pearson Prentice Hall, Inc. 2005.

2. Hugh D. Young, Roger A. Freedman. University Physics with Modern Physics. Pearson Addison Wesley, 2004.

3. Paul E. Tippens. Physics, Sixth Edition, Mc Graw-Hill, Columbus, Ohio, USA, 2011.

4. A. Serway, J. Jewett. Physics for Scientists and Engineers, 6th Edition Thomson Brooks/Cole, 2004.

Contents

Kazakh-British Technical University

Teaching Aid

V.V. Voronkov, F.F. Umarov

PROBLEMS FOR THE COURSE OF CLASSICAL PHYSICS (PHYSICS I)

Computer preparation V.V. Voronkov

Sign to print "___" May 2012
Circulation 100 copy. Size 60x84 1/16. Paper printing
Volume 6 ed.publ.p. Order N

Publication of Kazakh-British Technical University
@ Publishing House of the Kazakh-British Technical University, Almaty, Tole bi, 59.