AP Physics C Summer Assignment

Kinematics

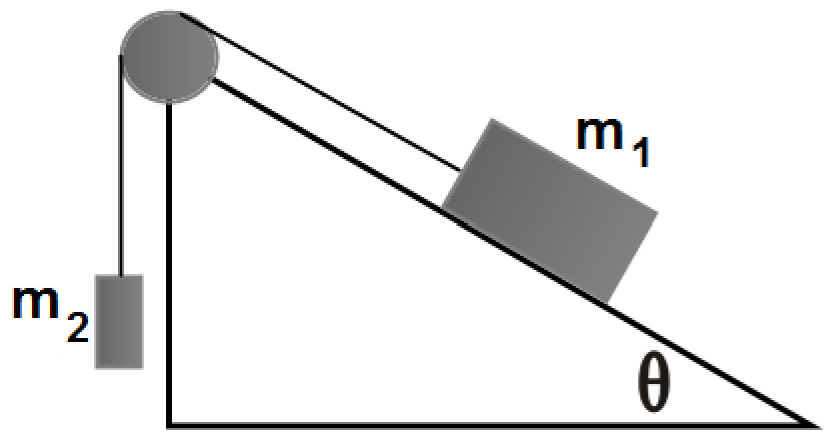
1. A bus makes three displacements I the following order:
   1) 58 mi, 38˚ east of north
   2) 69 mi, 46˚ west of north; and
   3) 75 mi, south-east

   a. Draw a clear diagram showing all three displacement vectors with respect to horizontal points (north, east, south, and west).
   b. Find the X and Y components of displacement D_1.
   c. Find the X and Y components of displacement D_2.
   d. Find the X and Y components of displacement D3.
   e. Find the magnitude of the resultant vector.
   f. Find the direction of the resultant vector.

2. A ball is thrown horizontally from the roof of a building 75 m tall with a speed of 4.6 m/s.
   a. How much later does the ball hit the ground?
   b. How far from the building will it land?
   c. What is the velocity of the ball just before it hits the ground?

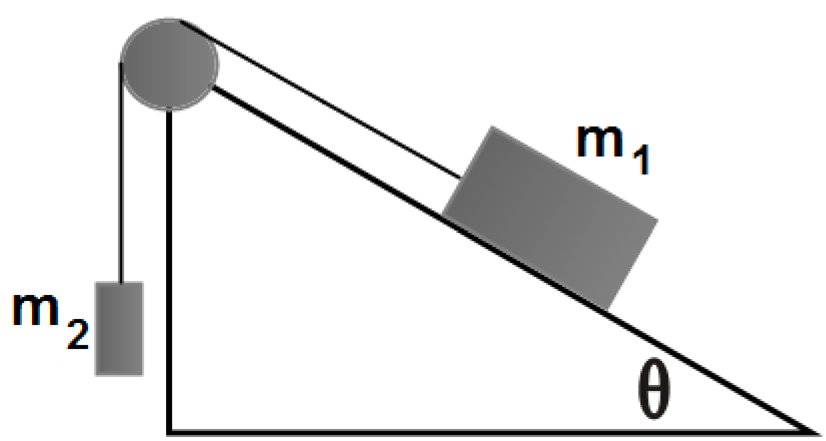
3. A projectile is fired with an initial speed of 150 m/s at an angle of 47˚ above the horizontal.
   a. Determine the total time in the air.
   b. Determine the maximum height reached by the projectile.
   c. Determine the maximum horizontal distance covered by the projectile.
   d. Determine the velocity of the projectile 5 s after firing.

Dynamics

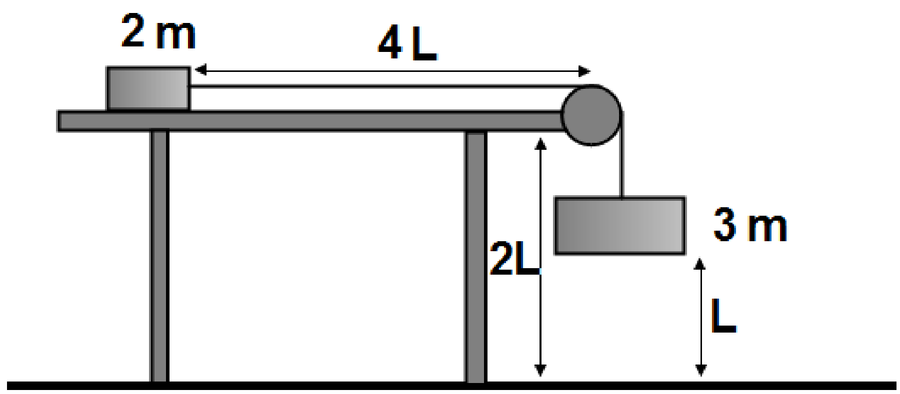


1. Two blocks with masses m_1 and m_2, respectively, are connected by a light string. Block 1 is placed on an inclined plane which makes an angle θ with the horizontal. Block 2 is suspended from a pulley that is attached to the top on the inclined plane. The coefficient of kinetic friction between block 1 and the incline is μ.

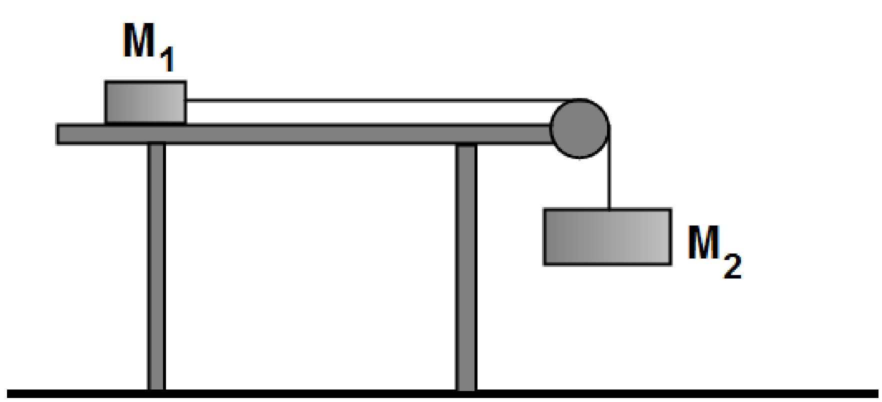
   a. Block 1 moves up the inclined plane with a constant velocity v. On the diagram below show all the applied force on each block.



   b. Determine the mass of block 2 that allows block 1 to move up the incline with a constant speed.
   c. Determine the mass of block 2 that will cause block 1 to accelerate up the incline at a constant rate a.
   d. The string between the blocks is cut. Determine the acceleration of block 1.

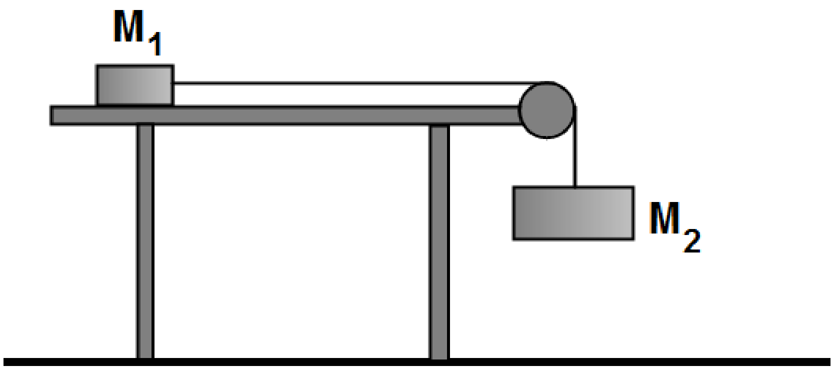


2. In the system presented on the diagram, block 2m and block 3m are connected by a light string passing over a frictionless pulley. Block 2m is placed on the surface of a horizontal table with negligible friction. Present all answers in terms of m, l, and fundamental constants.
   a. Determine the acceleration of the system after it is released from rest.
   b. Determine the velocity of 3m block just before it hits the floor.
   c. Determine the velocity of 2m block at the edge of the table.
   d. Determine the distance between the blocks after they landed on the floor.



3. Block M_1 is connected to block M_2 by a light string that passes over a frictionless pulley. Block M_1 is placed on a rough horizontal table. The coefficients of static and kinetic friction between the surface and block M_1 are μs and μk respectively.

a. On the diagram below show all the applied force on each block.



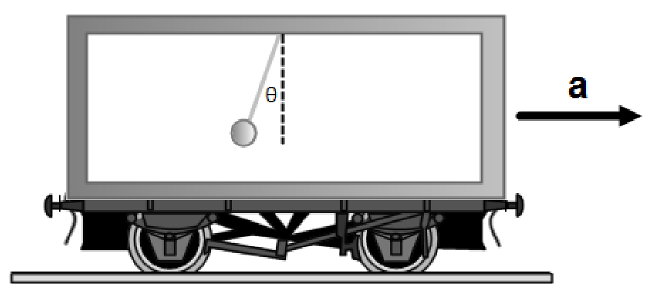
b. Determine the minimum value of coefficient of static friction, which will prevent the blocks from moving.

An extra mass Δm is placed on the top of block M_2, the extra mass causes the system of two blocks to accelerate.

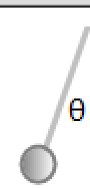
c. Determine the acceleration of the system.

D. Determine the tension force in the string.

4. A railroad wagon accelerates from rest. A small metallic sphere of mass m is suspended at the end of a light string which attached to the wagon's ceiling and makes an angle θ with the vertical.



a. On the diagram to the right, draw a free-body diagram of the sphere.



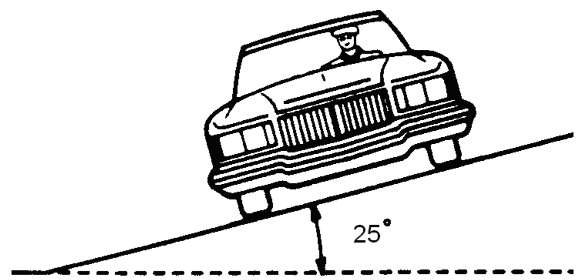
The wagon accelerates for a total 30 s and reaches a velocity of 15 m/s.

b. Determine the acceleration of the wagon.

c. Determine the angle θ between the string and the vertical during the acceleration of the wagon.

Circular Motion

1. A curve with a radius of 50 m is banked at an angle of 25˚. The coefficient of static friction between the tires and the roadway is 0.3.



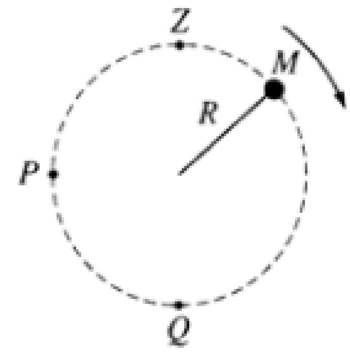
   a. Find the correct speed of an automobile that does not require any friction force to prevent skidding.

   b. What is the maximum speed the automobile can have before sliding up the banking?

   c. What is the minimum speed the automobile can have before sliding down the banking?

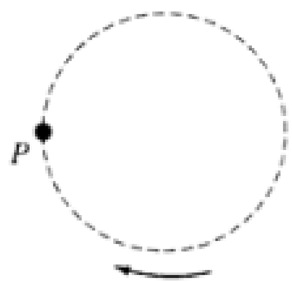
   a. Determine the horizontal distance the ball travels before hitting the ground.

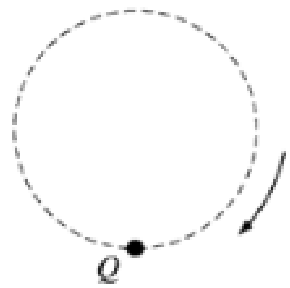
2. A ball of mass M is attached to a string of length R and negligible mass. The ball moves clockwise in a vertical circle, as shown above. When the ball is at point P, the string is horizontal. Point Q is at the bottom of the circle and point Z is at the top of the circle. Air resistance is negligible. Express all algebraic answers in terms of the given quantities and fundamental constants.



Side View

   a. On the figures below, draw and label all the forces exerted on the ball when it is at points P and Q, respectively.

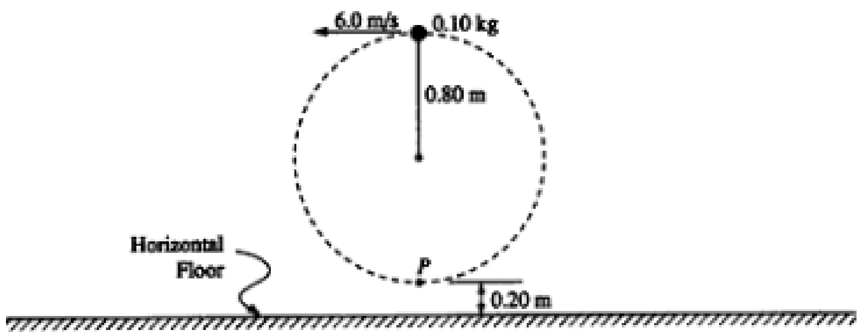




   b. Derive an expression for v_{min} the minimum speed the ball can have at point Z without leaving the circular path.

   c. The maximum tension the string can have without breaking is T_{max} Derive an expression for v_{max}, the maximum speed the ball can have at point Q without breaking the string.

   d. Suppose that the string breaks at the instant the ball is at point P. Describe the motion of the ball immediately after the string breaks.



3. A 0.10-kilogram solid rubber ball is attached to the end of an 0.80-meter length of light thread. The ball is swung in a vertical circle, as shown in the diagram above. Point P, the lowest point of the circle, is 0.20 meter above the floor. The speed of the ball at the top of the circle is 6.0 meters per second, and the total energy of the ball is kept constant.

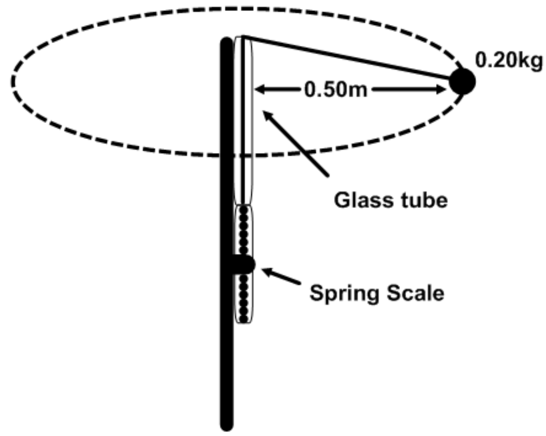
   a. Determine the total energy of the ball, using the floor as the zero point for gravitational potential energy.

   b. Determine the speed of the ball at point P, the lowest point of the circle.

   c. Determine the tension in the thread at
      i. the top of the circle;
      ii. the bottom of the circle.

   The ball only reaches the top of the circle once before the thread breaks when the ball is at the lowest point of the circle.

   d. Determine the horizontal distance that the ball travels before hitting the floor.



4. To study circular motion, two students use the hand-held device shown above; this consists of a rod on which a spring scale is attached. A polished glass tube attached at the top serves as a guide for a light cord attached the spring scale. A ball of mass 0.200 kg is attached to the other end of the cord. One student swings the teal around at constant speed in a horizontal circle with a radius of 0.500 m. Assume friction and air resistance are negligible.

a. Explain how the students, by using a timer and the information given above, can determine the speed of the ball as it is revolving.

b. How much work is done by the cord in one revolution? Explain how you arrived at your answer.

c. The speed of the ball is determined to be 3.7 m/s. Assuming that the cord is horizontal as it swings, calculate the expected tension in the cord.

d. The actual tension in the cord as measured by the spring scale is 5.8 N. What is the percent difference between this measured value of the tension and the value calculated in part c.?

e. The students find that, despite their best efforts, they cannot swing the ball so that the cord remains exactly horizontal.

    i. On the picture of the ball, draw vectors to represent the forces acting on the ball and identify the force that each vector represents.

    ii. Explain why it is not possible for the ball to swing so that the cord remains exactly horizontal.

    Calculate the angle that the cord makes with the horizontal.

Universal Gravity

1. During a lunar eclipse, the Moon, Earth, and Sun all lie on the same line, with the Earth between the Moon and the Sun. The Moon has a mass of 7.4×10^{22} kg; Earth has a mass of 6.0×10^{24} kg; and the Sun has a mass of 2.0×10^{30} kg. The separation between the Moon and the Earth is given by 3.8×10^{8} m; the separation between the Earth and the Sun is given by 1.5×10^{11} m.

   (a) Calculate the force exerted on Earth by the Moon.

   (b) Calculate the force exerted on Earth by the Sun.

   (c) Calculate the net force exerted on Earth by the Moon and the Sun.

2. A 2.10-kg brass ball is transported to the Moon. (The radius of the Moon is 1.74×10^{6} m and its mass is 7.35×10^{22} kg.)

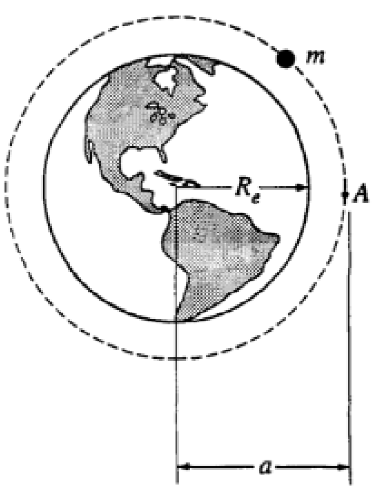
   (a) Calculate the acceleration due to gravity on the Moon.

   (b) Determine the mass of the brass ball on Earth and on the Moon.

   (c) Determine the weight of the brass ball on Earth.

   (d) Determine the weight of the brass ball on Moon.

3. A satellite of mass m is in a circular orbit around the Earth, which has mass M_e and radius R_e. Express your answers in terms of a, m, M_e, R_e, and G.



   (a) Write the equation that can describe the gravitational force on the satellite.

   (b) Write an equation that can be used to find the acceleration of the satellite.

   (c) Find the acceleration of the satellite when it stays on the same orbit with the radius a. Is this acceleration greater, less than the acceleration g on the surface of Earth?

   (d) Determine the velocity of the satellite as it stays on the same orbit.

   (e) How much work is done the gravitational force to keep the satellite on the same orbit?

   (f) What is the orbital period of the satellite?

4. A satellite is placed into a circular orbit around the planet Jupiter, which has mass M_J = 1.90 x 10^{27} kg and radius R_J = 7.14 x 10^7 m.

   (a) If the radius of the orbit is *R,* use Newton's laws to derive an expression for the orbital velocity.

   (b) If the satellite increases its orbital radius, how it would change the orbital velocity? Explain.

   (c) If the radius of the orbit is R, use Newton's laws to derive an expression for the orbital period.

   (d) The satellite rotation is synchronized with Jupiter's rotation. This requires an equatorial orbit whose period equals Jupiter's rotation period of 9 hr 51 min = 3.55*10^4 s. Find the required orbital radius.

5. The Sojourner rover vehicle was used to explore the surface of Mars as part of the Pathfinder mission in 1997. Use the data in the tables below to answer the questions that follow.

   Mars Data
   Radius: 0.53 x Earth's radius
   Mass: 0.11 x Earth's mass

   Sojourner Data
   Mass of Sojourner vehicle: 11.5 kg
   Wheel diameter: 0.13 m
   Stored energy available: 5.4 x 10^5 J
   Power required for driving under average conditions: 10 W
   Land speed: 6.7 x 10^{-3} m/s

   (a) Determine the acceleration due to gravity at the surface of Mars in terms of g, the acceleration due to gravity at the surface of Earth.

   (b) Calculate Sojourner's weight on the surface of Mars.

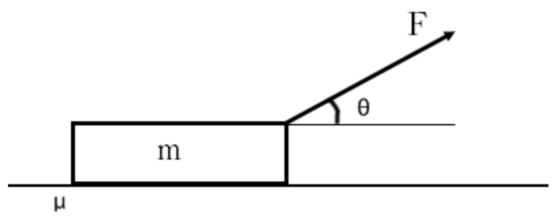
   (c) Assume that when leaving the Pathfinder spacecraft Sojourner rolls down a ramp inclined at 20° to the horizontal. The ramp must be lightweight but strong enough to support Sojourner. Calculate the minimum normal force that must be supplied by the ramp.

   (d) What is the net force on Sojourner as it travels across the Martian surface at constant velocity? Justify your answer.

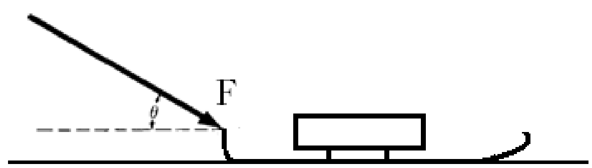
   (e) Determine the maximum distance that Sojourner can travel on a horizontal Martian surface using its stored energy.

   (f) Suppose that 0.010% of the power for driving is expended against atmospheric drag as Sojourner travels on the Martian surface. Calculate the magnitude of the drag force.

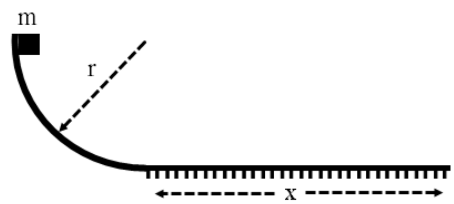
Energy



1. A 50 kg block is pulled from rest by a force of 1000 N at 37° across a horizontal rough surface over a distance of 5.6 m. The coefficient of kinetic friction between the block and the surface is 0.5.
    a. Draw a free-body diagram and show all the applied forces.
    b. How much work is done by force F?
    c. How much work is done by the normal force?
    d. How much work is done by the gravitational force?
    e. How much work is done by the friction force?
    f. What is the net work done on the block?
    g. What is the change in kinetic energy of the block?



2. A boy pushes a 10 kg sled at a constant speed by applying a force of 75 N at 30° with respect to the horizontal. The sled is pushed over a distance of 15 m.
    a. Draw a free-body diagram and show all the applied forces.
    b. How much work is done by force F?
    c. How much work is done by the normal force?
    d. How much work is done by the gravitational force?
    e. How much work is done by the friction force?
    f. What is the coefficient of kinetic friction between the sled and the surface?
    g. How much work is done by the net force on the sled?



3. A 5 kg block is released from rest at the top of a quarter-circle type curved frictionless surface. The radius of the curvature is 3.8 m. When the block reaches the bottom of the curvature it then slides on a rough horizontal surface until it comes to rest. The coefficient of kinetic friction on the horizontal surface is 0.02.

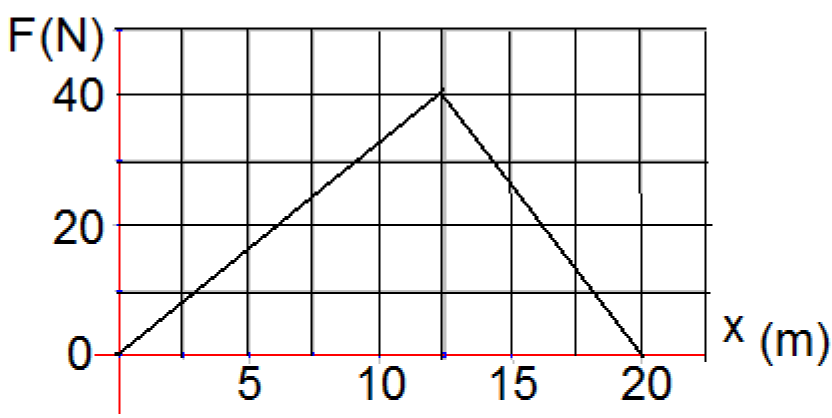
   a. What is the kinetic energy of the block at the bottom of the curved surface?

   b. What is the speed of the block at the bottom of the curved surface?

   c. Find the stopping distance of the block?

   d. Find the elapsed time of the block while it is moving on the horizontal part of the track.

   e. How much work is done by the friction force on the block on the horizontal part of the track?



4. A 5 kg object is initially at rest at $x_0 = 0$. A non-constant force is applied to the object. The applied force as a function of position is shown on the graph.

   a. How much work is done on the object during first 12.5 m?

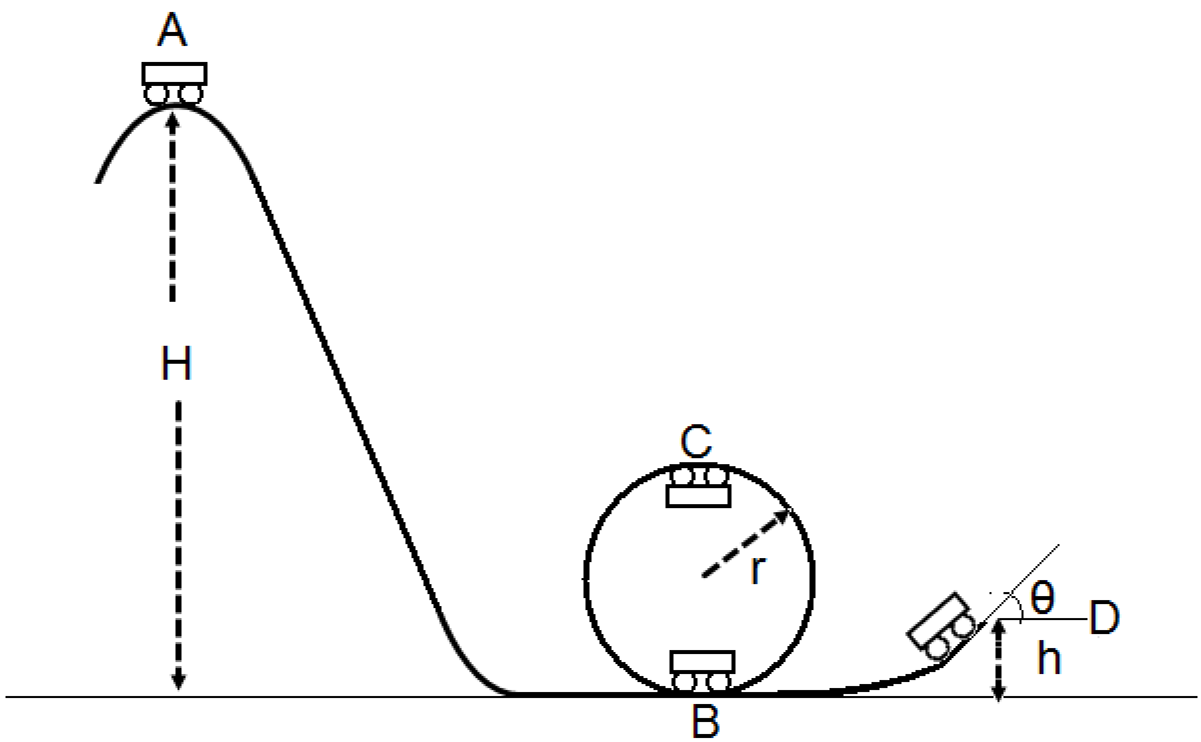
   b. What is the change is kinetic energy at the end of 12.5 m?

   c. What is the speed of the object at the end of 12.5 m?

   d. What is the total work done by the force for the entire trip?

   e. What is the change in kinetic energy for the entire trip?

   f. What is the speed of the object at the end of 20 m?



5. A 900 kg roller coaster car starts from rest at point A rolls down the track and then goes around a loop and when it leaves the loop flies off the inclined part of the track. All the dimensions are: H = 80 m, r = 15 m, h = 10 m, ϴ = 30̊.

   a. What is the speed of the car at point B?

   b. What is the speed of the car at point C?

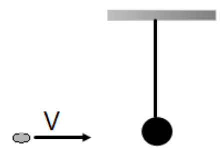
   c. What is the speed of the car at point D?

   d. What is the force applied by the surface on the car at point B?

   e. What is the force applied by the surface on the car at point C?

   f. How far from point D will the car land?

Momentum



1. A 20 g piece of clay moves with a constant speed of 15 m/s. The piece of clay collides and sticks to a massive ball of mass 900 g suspended at the end of a string.

    a. Calculate the momentum of the piece of clay before the collision.

    b. Calculate the kinetic energy of the piece of clay before the collision.

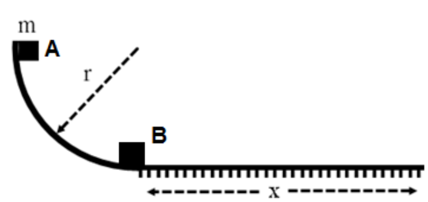
    c. What is the momentum of two objects after the collision?

    d. Calculate the velocity of the combination of two objects after the collision.

    e. Calculate the kinetic energy of the combination of two objects after the collision.

    f. Calculate the change in kinetic energy during the collision.

    g. Calculate the maximum vertical height of the combination of two objects after the collision.



2. Block A with a mass of m is released from the top of the curved track of radius r. Block A slides down the track without friction and collides inelastically with an identical block B initially at rest. After the collision the two blocks move distance X to the right on the rough horizontal part of the track with a coefficient of kinetic friction μ.

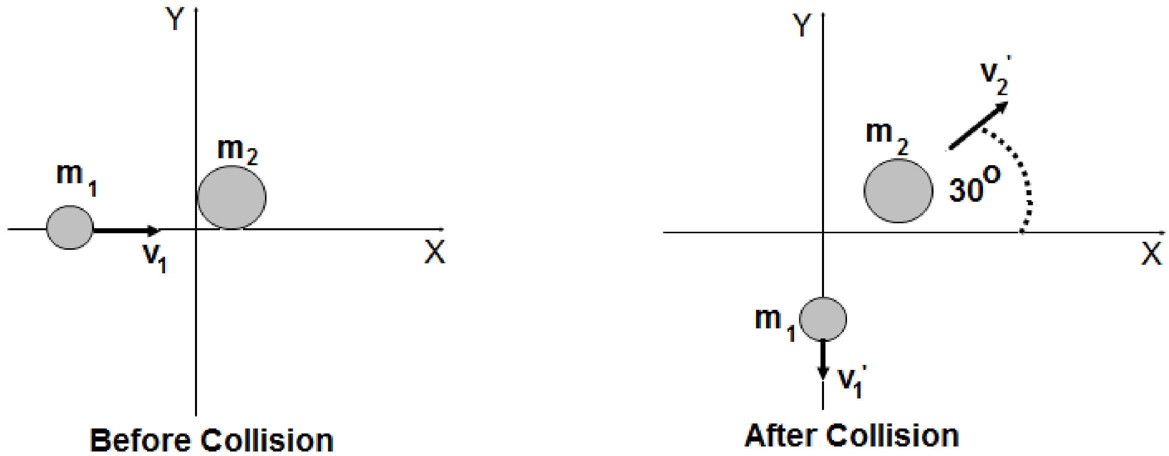
    a. What is the speed of block A just before it hits block B?

    b. What is the speed of the system of two blocks after the collision?

    c. What is the kinetic energy of the system of two blocks after the collision?

d. How much energy is lost due to the collision?

e. What is the stopping distance X of the system of two blocks?



3. Two discs of masses m_1 = 2kg and m_2 = 8 kg are placed on a horizontal frictionless surface. Disc m_1 moves at a constant speed of 8 m/s in +x direction and disc m_2 is initially at rest. The collision of two discs is perfectly elastic and the directions of two velocities presented by the diagram.

   a. What is the x- component of the initial momentum of disc m_1?

   b. What is the y- component of the initial momentum of disc m_1?

   c. What is the x- component of the initial momentum of disc m_2?

   d. What is the y- component of the initial momentum of disc m_2?

   e. What is the x- component of the final momentum of disc m_1?

   f. What is the x-component of the final momentum of disc m_2?

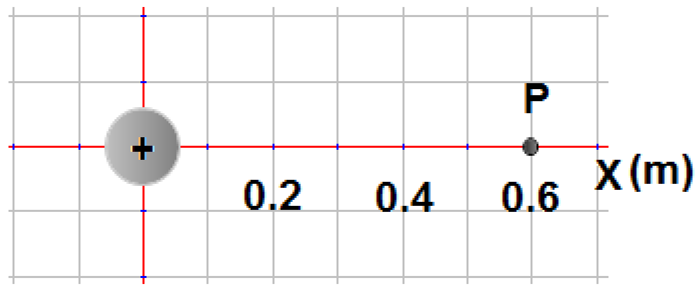
   g. What is the y-component of the final momentum of disc m_2?

   h. What is the final vector velocity of m_2?

   i. What is the y-component of the final momentum of disc m_1?

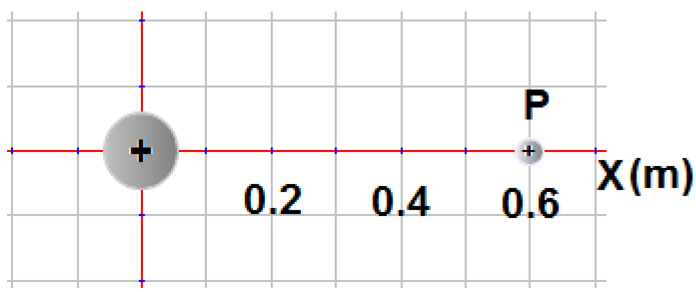
   j. What is the final vector velocity of disc m_1?

Electrostatics



1. A charged sphere A has a charge of +9 μC and is placed at the origin.
   a. What is the electric potential at point P located 0.6 m from the origin?

A point charge with a charge of+3 μC and mass of 5 g is brought from infinity to point P.



   b. How much work is done to bring the point charge from infinity to point P?
   c. What is the electric force between two charges?
   d. What is the net electric field at point 0.3 m from the origin?

The sphere stays fixed and point charge is released from rest.

   e. What is the speed of the point charge when it is far away from the origin?

2. Two charges are separated by a distance of 0.5 m. Charge Q_1 = -9 μC. The electric field at the origin is zero.

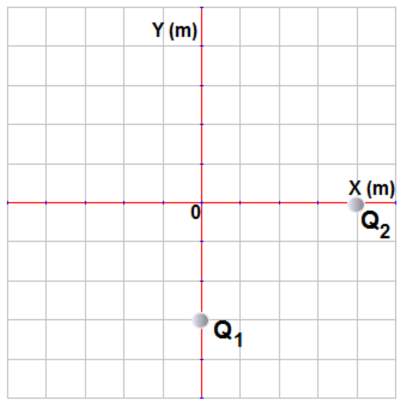
a. What is the magnitude and sign of charge Q_2?

b. What is the magnitude and direction of the electric force between the charges?

c. What is the electric energy of the system of two charges?

d. What is the net electric potential at the origin?

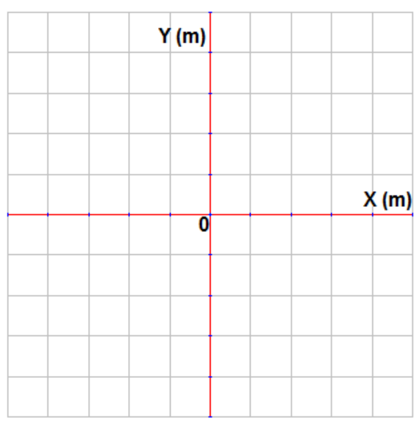
e. How much work is required to bring a negative charge of -1 nc from infinity to the origin?



3. A charge Q_1 = +9 μC is placed on the y-axis at -3 m, and charge Q_2 = -16 μC is placed at the x-axis at +4 m.

a. What is the magnitude of the electric force between the charges?

b. On the diagram below show the direction of the net electric field at the origin.



c. What is the magnitude of the net electric field at the origin?

d. What is the electric energy of the system of two charges?

e. What is the net potential at the origin?

f. How much work is required to bring a small charge +1 nC from infinity to the origin?

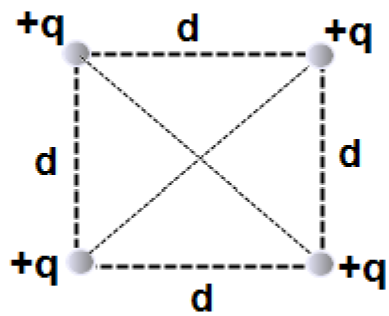


Figure 1

4. Four equal and positive charges +q are arranged as shown on figure 1.

   a. Calculate the net electric field at the center of square?
   b. Calculate the net electric potential at the center of square?
   c. How much work is required to bring a charge q_0 from infinity to the center of square?

Two positive charges are replaced with equal negative charges, figure 2.

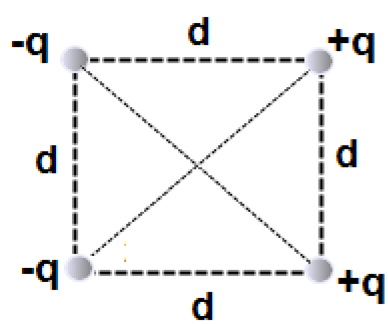
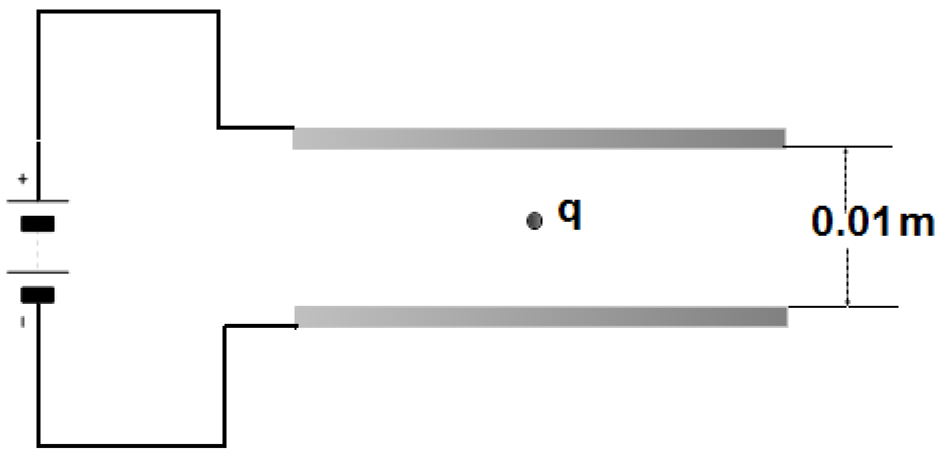


Figure 2

   d. Calculate the net electric field at the center of square.
   e. Calculate the net electric potential at the center of square.
   f. How much work is required to bring a charge q0 from infinity to the center of square?



5. In an oil-drop experiment, two parallel conducting plates are connected to a power supply with a constant voltage of 100 V. The separation between the plates is 0.01 m. A $4.8x10^{-16}$ kg oil drop is suspended in the region between the plates. Use g = 10 m/s^2.

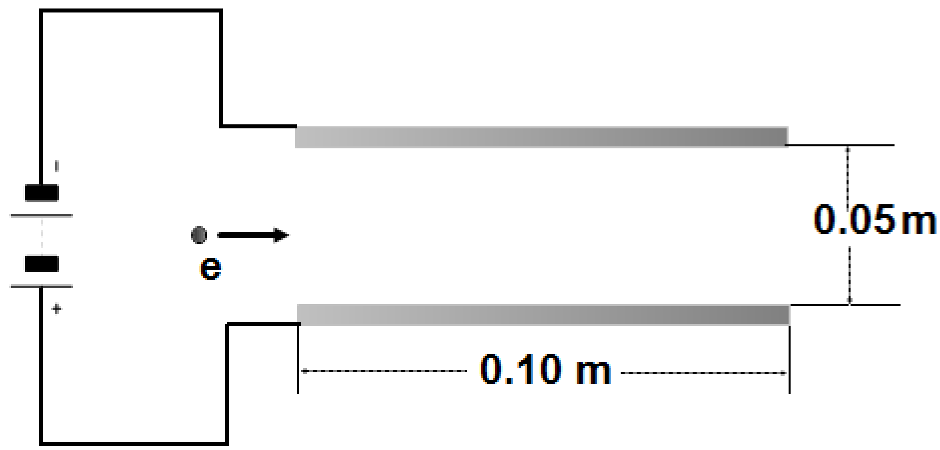
    a. What is the direction of the electric field between the plates?

    b. What is the magnitude of the electric field between the plates?

    c. What is the sign and magnitude of the electric charge on the oil drop when it stays stationary?

The mass of the drop is reduced to $3.2*10^{-16}$ kg because of vaporization.

    d. What is the acceleration of the drop?



6. A parallel-plate capacitor is connected to a battery with a constant voltage of 120 V. Each plate has a length of 0.1 m and they are separated by a distance of 0.05 m. An electron with an initial velocity of $2.9*10^7$ m/s is moving horizontally and enters the space between the plates. Ignore gravitation.
   a. What is the direction of the electric field between the plates?

   b. Calculate the magnitude of the electric field between the plates.

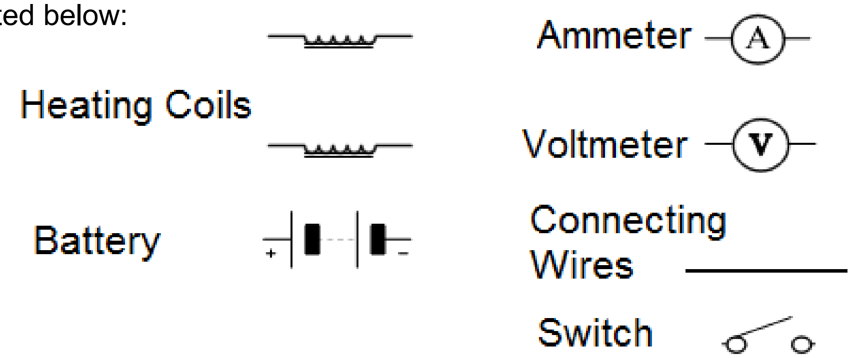
   c. Describe the electron's path when it moves between the plates.

   d. What is the direction and magnitude of its acceleration?

   e. Will the electron leave the space between the plates?

Electric Current and Circuits

1. A physics student has an assignment to make an electrical heating system with the set of materials listed below:

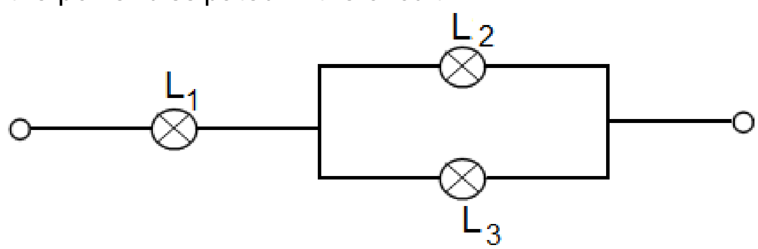


   a. In a space below draw a diagram showing all the elements connected in one electrical circuit that can provide the maximum rate of heat produced. Use two meters in your circuit, they will help to measure the heat rate.

   The battery has an emf of 12 V and an internal resistance of 0.5 Ω and each heating coil has a resistance of 17.3 Ω.

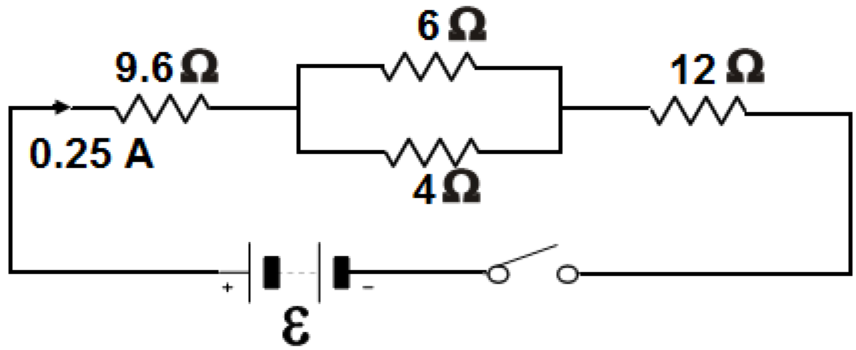
   b. When the switch is closed, what is the current running through the battery?
   c. What is the terminal voltage on the battery?
   d. What is the rate of energy delivered by the heating system?
   e. If the switch is closed for 5 min, what is the total energy dissipated in the coils?

2. An electric motor in a toy car can operate when connected to a 6 V battery and has a current of 0.5 A. A physics student wants to run the toy car but unfortunately he could find a 12 V battery in the physics lab. The student also found a box with a set of five 6-Ω resistors.
   a. Use given materials design an electric circuit in which the electric motor will operate properly.
      i. Draw the circuit including all devices.
      ii. Explain your reasoning in designing this particular circuit.
   b. Calculate the net resistance of the circuit.
   c. Calculate the power dissipated in the circuit.



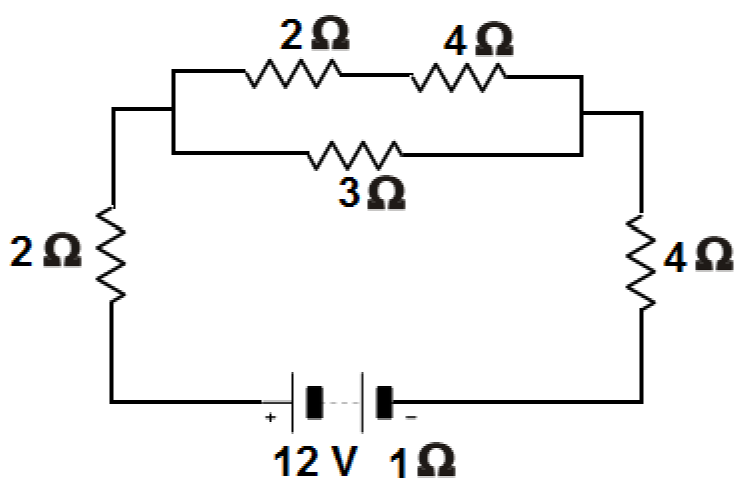
3. Three light bulbs are connected in the circuit show on the diagram. Each light bulb can develop a maximum power of 75 W when connected to a 120-V power supply. The circuit of three light bulbs is connected to a 120 V power supply.

   a. What is the resistance of the circuit?
   b. What is the power dissipated by the circuit?
   c. How would you compare this power to the power when all bulbs are connected in parallel?
   d. What is the current in light bulb L_1?
   e. What is the voltage across light bulb L_1?
   f. What is the voltage across light bulb L_2?



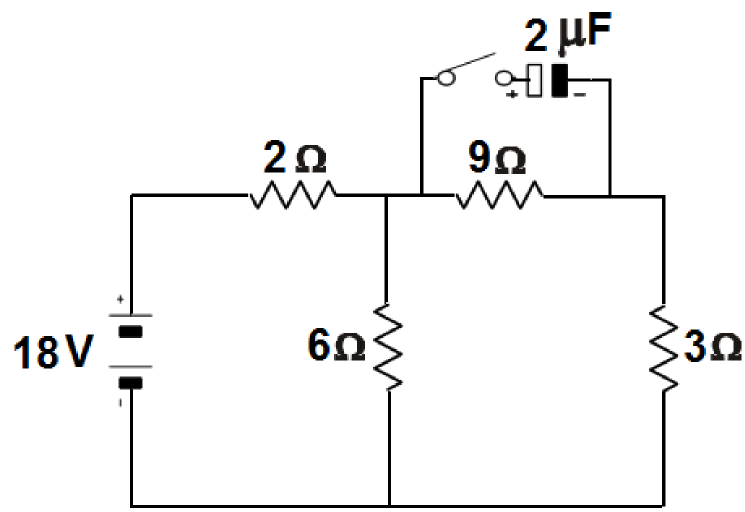
4. Four resistors are connected in a circuit. The circuit is connected to a battery with emf ε and negligible internal resistance. The current through 9.6 Ω resistor is 0.25 A.

   a. What is the net resistance of the circuit?
   b. What is the voltage drop across 6- Ω resistor?
   c. What is the current in 4- Ω resistor?
   d. What is the emf of the battery?
   e. What is the net power dissipation?



5. Five resistors are connected to a battery with an emf of 12 V and an internal resistance of 1 Ω.

   a. Calculate the external resistance of the circuit.
   b. Calculate the current in the battery.
   c. Calculate the terminal voltage of the battery.
   d. Calculate the power dissipation in the 3- Ω resistor.
   e. Calculate the power dissipation in the internal resistance.



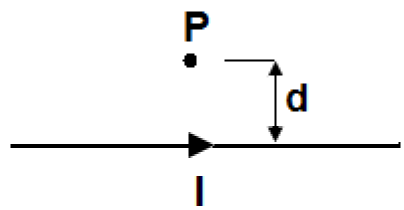
6. Four resistors and a capacitor are connected to an 18 V battery with negligible internal resistance, as shown on the diagram. Initially the capacitor is disconnected from the battery – switch is open

   a. Calculate the net resistance of the circuit.
   b. Calculate the current in the 2-Ω resistor.
   c. Calculate the current in the 3-Ω resistor.

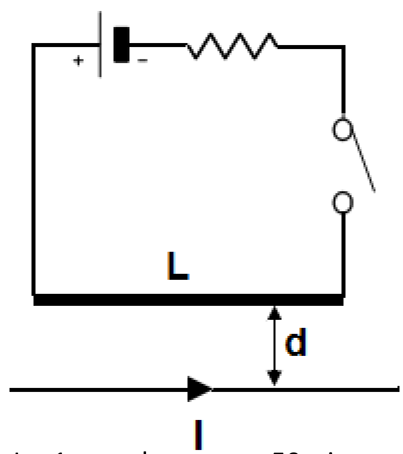
Switch is closed and the current reached constant value.

   d. Calculate the charge on the capacitor.
   e. Calculate the energy stored in the capacitor.

Magnetism



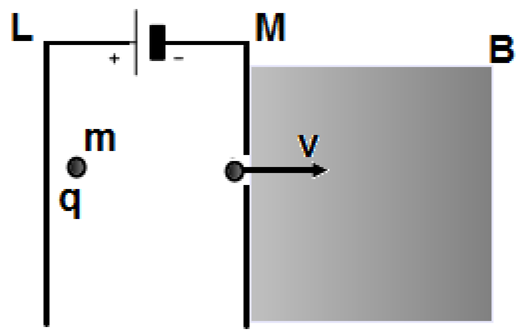
1. A long horizontal wire carries an electric current I = 50 A. Point P is located at a distance 2.5 mm above the current.
    a. What is the direction of the magnetic field at point P?
    b. What is the magnitude of the magnetic field at point P?



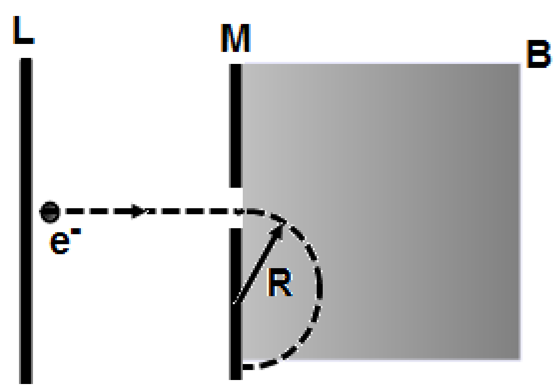
A thin horizontal rod has a length L = 1 m and mass m = 50 g is connected to a circuit. The circuit contains a battery V = 12 V, a resistor R = 0.06 Ω, a switch, and connecting wires. The rod is supported in horizontal position by two light connecting wires.

   c. What is the direction of the electric current in the rod?
   d. On the diagram below show all the applied forces on the rod.

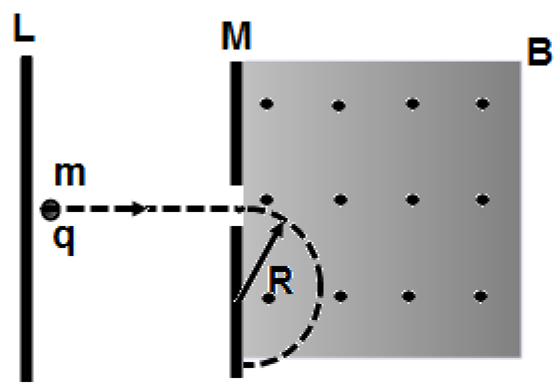
   e. What is the tension force in supporting wires?



2. Charged particle of mass m and charge q is released from rest in region between two charged plates M and L. After passing the region of the electric field with an accelerating voltage V_a the particle enters another region filled with a magnetic field of magnitude B and directed out of the page.
   a. What is the sign of the charge on the particle?
   b. What is the velocity of the particle as it enters the magnetic field?
   c. What is the direction of the magnetic force on the particle?
   d. Describe the path of the particle in the magnetic field.
   e. What is the radius of the curvature of the particle in the magnetic field?
   f. What is the direction and magnitude of the electric field that can be used to make the path of the particle straight?

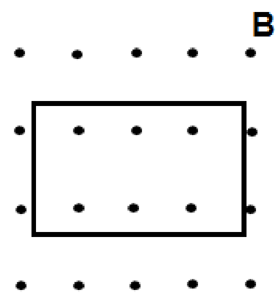


3. An electron is accelerated by an electric field produced by two parallel plates M and L. When the electron enters a region filled with a magnetic field of magnitude B = 0.5 T its velocity $v = 1.6 \cdot 10^7$ m/s.
   a. What is the direction of the accelerating electric field between the plates M and L?
   b. What is the accelerating voltage of the electric field?
   c. What is the direction of the magnetic field?
   d. What is the radius of the curvature of the electron in the magnetic field?
   e. What is the direction of the deflecting electric field required to make the electron's path straight?
   f. What is the magnitude of the deflecting electric field?

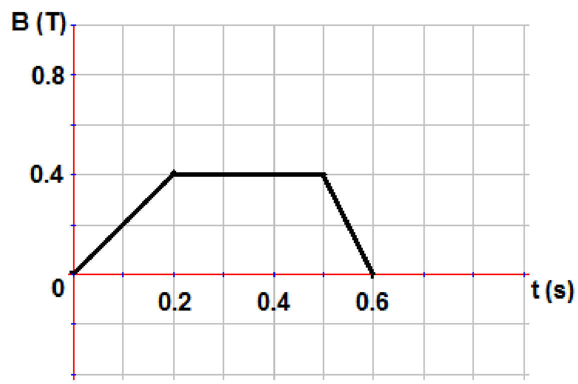


4. In a mass spectrometer a charged particle is accelerated to a velocity $v = 5.9 \cdot 10^7$ m/s by an electric field and allowed to enter a magnetic field B, where it is deflected in a semi-circular path of radius R = 10 cm. The magnetic field is uniform of magnitude B = 16 T and oriented out of the page.
   a. What is the sign of the charge on the particle?
   b. What is the acceleration of the particle in the magnetic field?
   c. What is the ratio between the charge and mass of the particle q/m?
   d. What is the direction of the accelerating electric field?
   e. What is the accelerating voltage of the electric field?

Electro-Magnetic Induction



1. A 0.2 Ω rectangular loop of wire has an area of 0.5 m^2 and placed in a region where magnetic field changes as shown on the diagram.



   a. What is the magnetic flux in the loop at 0.4 s?

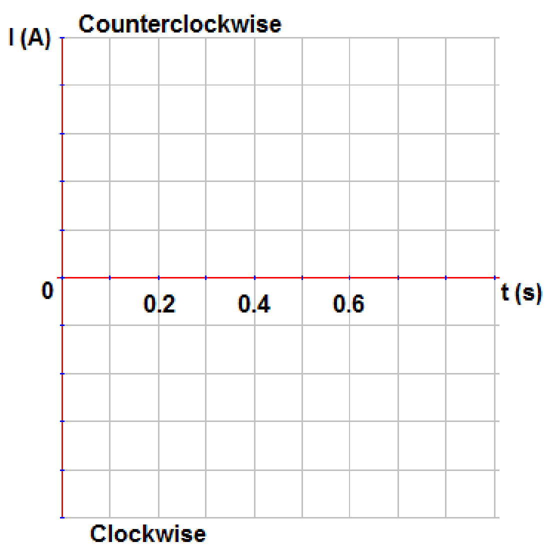
   b. What is the induced emf for the following time?

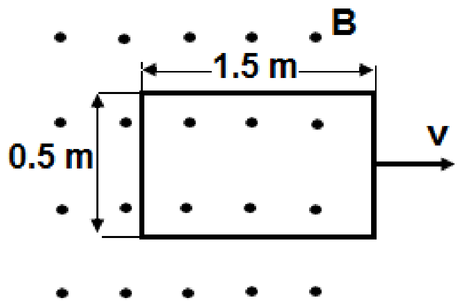
i. ________ 0.1 s ii. __________0.3 s iii. __________ 0.5 s

   c. What is the induced current for the following time?

i. ________ 0.1 s ii. __________0.3 s iii. __________ 0.5 s

   d. On the diagram below graph the induced current as a function of time.





2. A rectangular loop of wire 0.5 m wide and 1.5 m long is moving out of a uniform magnetic field B = 2 T at a constant speed of 2m/s. The left side of the loop stays inside the field when the right side is out. The resistance of the loop is 0.5 Ω.

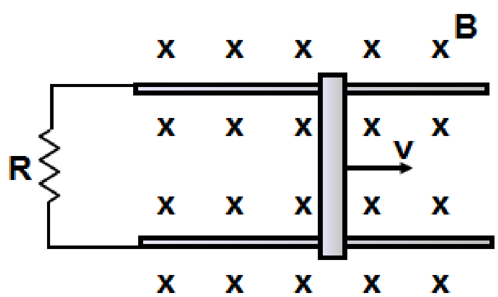
    a. What is the direction of the induced current in the loop?

    b. Calculate the induced emf in the loop.

    c. Calculate the induced current in the loop.

    d. Calculate the applied force required to move the loop at the constant speed.

    e. Calculate the power developed by the force.



3. A metallic rod has a length L and slides at a constant speed v on the top of two conducting parallel rails. The rails are connected to a resistor R. The apparatus is placed in a uniform magnetic field B which is perpendicular to the plane where rod is moving.

    a. What is the direction of the induced current?

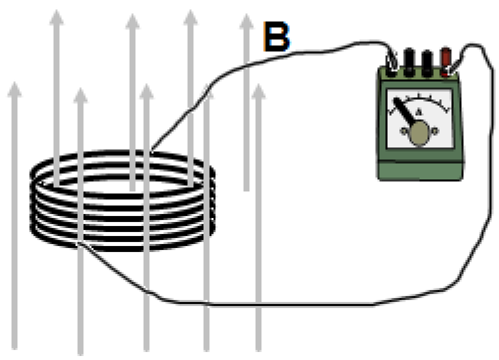
    b. Determine the induced emf.

    c. Determine the induced current in the circuit.

    d. Determine the electric field E induced in the rod.

    e. Determine the force required to move the rod at the constant speed.

    f. Determine the power dissipated in the resistor when the rod crosses the magnetic field.



4. A coil 30 cm in diameter consist of 20 turns of circular copper wire 2 mm in diameter. The coil is connected to a low resistance galvanometer. Initially coil is placed in a uniform magnetic field perpendicular to its plane. During the experiment the magnetic field changes from 0.5 T to 2.5 T in 0.4 s. Ignore the resistance of the connecting wires.(copper resistivity $1.68 \cdot 10^{-8} \Omega \cdot m$)

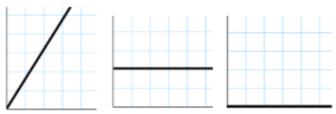
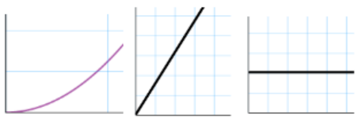
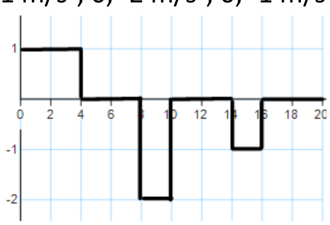
   a. Calculate the initial flux in the coil.

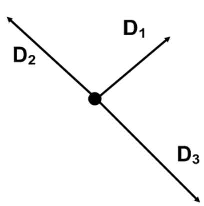
   b. Calculate the induced emf in the galvanometer.

   c. Calculate the induced current in the coil.

   d. Calculate the power dissipated in the coil as the field changes.

Answer Key
Kinematics

1. a. 333 m
   b. 40 m/s
   c. twice the speed
   d. 
   e. 
   f. $x = \left(20\frac{m}{s}\right)t$
   g. $x = \frac{1}{2}\left(2.4\frac{m}{s^2}\right)t$
2. a. 8 to 10 s
   b. 10 to 14 s
   c. 8 m
   d. 28 m
   e. 2.8 m/s
   f. 1 m/s^2, 0, -2 m/s^2, 0, -1 m/s^2, 0
   g. 

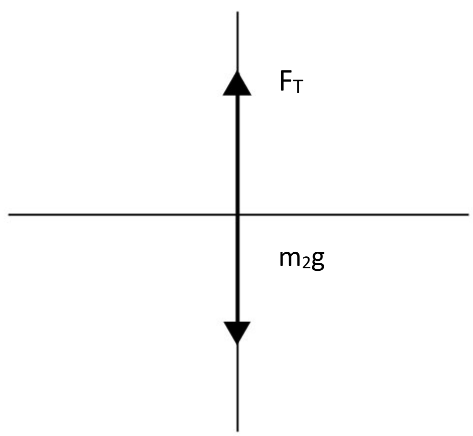


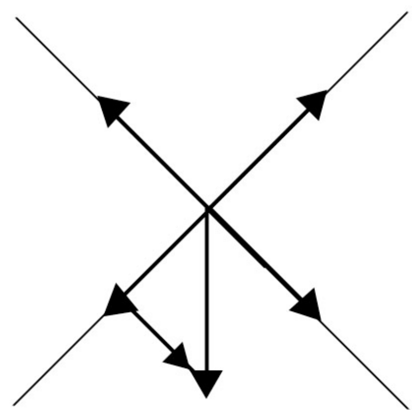
3. a.
   b. 35.7 mi and 45.7 mi
   c. -49.6 mi and 47.9 mi
   d. 53.0 mi and -53.0 mi
   e. 56.4 mi
   f. 46.1°

4. a. 3.9 s
   b. 18 m
   c. 39.3 m/s at 305°
5. a. 2 s
   b. 614°
   c. 2244 m
   d. 118 m
6. a. 8.4 s
   b. 14 m
   c. 335.2 m/s
   d. 65.7 m/s at 54°

Dynamics

1.





a)

b) $m_2 = m_1 (\sin \boldsymbol{\theta} + \boldsymbol{\mu}\, m_1 \cos \boldsymbol{\theta})$

c) $m_2 = \frac{m1\ (g \sin \theta + \mu g \cos\theta + a)}{(g - a)}$

d) $a = g \sin \boldsymbol{\theta} - \mu g \cos \boldsymbol{\theta}$
or
$a = g (\sin \boldsymbol{\theta} - \mu \cos \boldsymbol{\theta})$

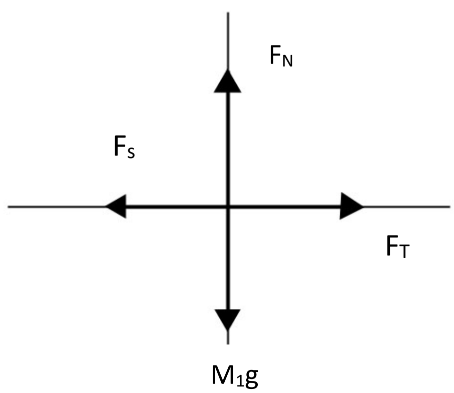
2.

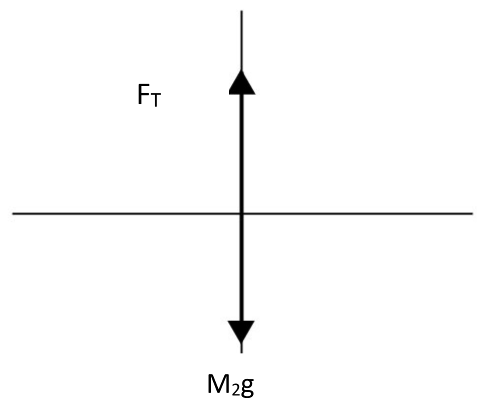
a) $a = 2\ m/s^2$
b) $T = 4.8\ N$
c) $F_{SUPP} = 9.6\ N$

3.

a) $a = 3/5\ g$
b) $v = \sqrt{(6gL/5)}$
c) $v = \sqrt{(6gL/5)}$
d) $x = 2L\sqrt{(6/5)}$

4.





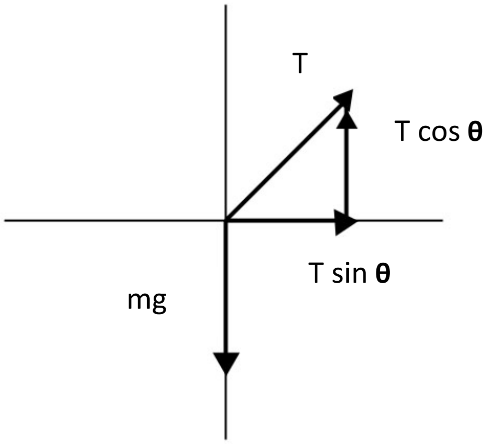
a)

b) $\boldsymbol{\mu_s} = M_2/M_1$

c) $a = \dfrac{g\ (M_2 + \Delta m - \mu M_1)}{M_1 + M_2 + \Delta m}$

d) $F_T = M_1 g\ (M + \dfrac{g\ (M_2 + \Delta m - \mu M_1)}{M_1 + M_2 + \Delta m})$

5.



a)

b) a = .5 m/s^2

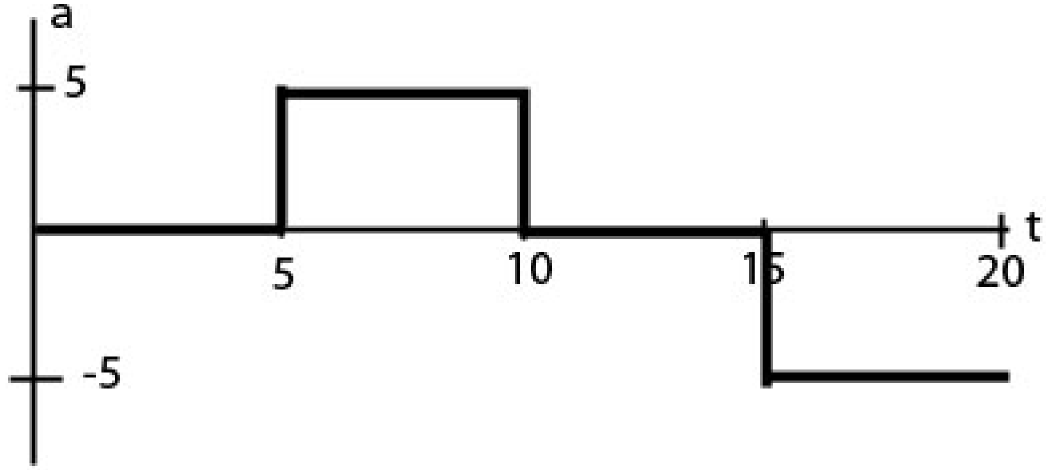
c) **θ** = 2.9^{O}

6.

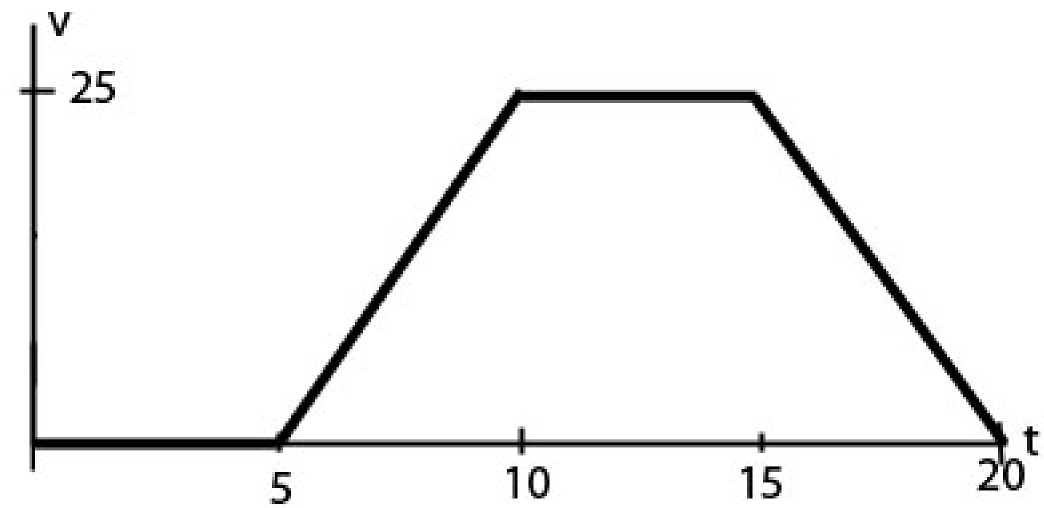
a) $a_{(0\text{-}5s)}$ = 0 m/s^2, $a_{(5\text{-}10s)}$ = 5 m/s^2, $a_{(10\text{-}15s)}$ = 0 m/s^2, $a_{(15\text{-}20s)}$ =-5 m/s^2

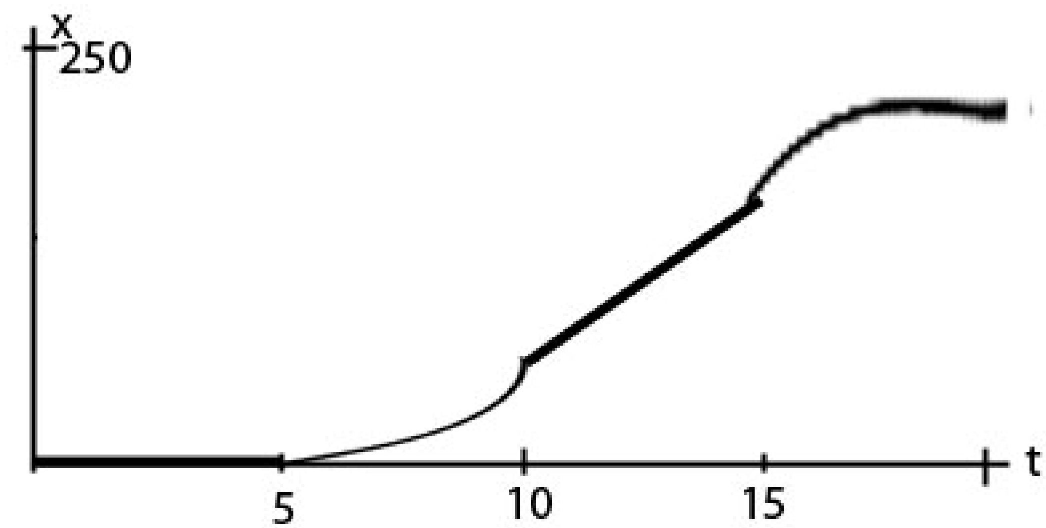
b) $v_{(0\text{-}5s)}$ = 0 m/s, $v_{(5\text{-}10s)}$ = 25 m/s, $v_{(10\text{-}15s)}$ = 25 m/s, $v_{(15\text{-}20s)}$ =0 m/s

c) $x_{(0\text{-}5s)}$ = 0 m, $x_{(5\text{-}10s)}$ = 62.5 m, $x_{(10\text{-}15s)}$ = 187.5 m, $x_{(15\text{-}20s)}$ =250 m



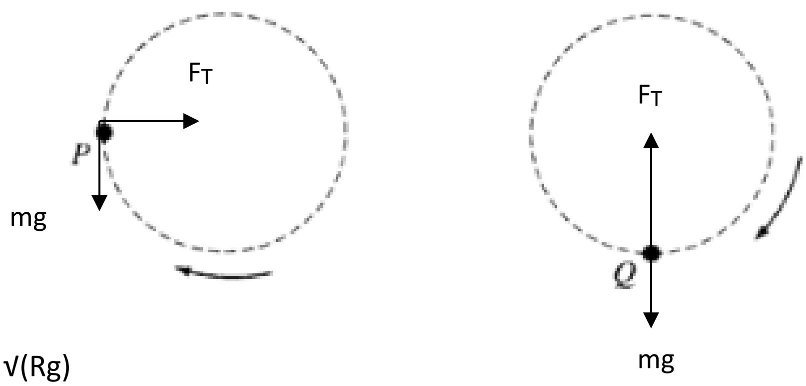
d)





Circular Motion

1. a. $v = 15$ m/s
   b. $v = 21.1$ m/s
   c. $v = 8.5$ m/s
2. a. $F_{NET} = 3$ Mg; F_{NET} is pointed downwards
   b. $v_O = \sqrt{(3Lg)}$
   c. $t = 2\sqrt{(L/g)}$
   d. $x = 2L\sqrt{3}$
3.
   a.



   b. $V_{min} = \sqrt{(Rg)}$
   c. $V = \sqrt{(R(\frac{T_{MAX}}{M} - g))}$
   d. Velocity is upwards, accelerati9on is g down
4. a. $E = 3.63$ J
   b. 8.2 m/s
   c. i. 3.5 N
      ii. 9.4 N
   d. 1.6 m

5. a. Get n and t

   Calculate T = $\frac{t}{n}$

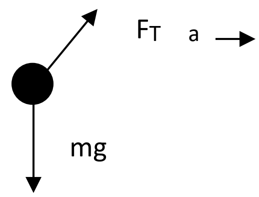
   Calculate v = $2\pi r/T$

   b. none, Δx = 0, also F is perpendicular to v

   c. T = 5.5 N

   d. % difference = 5%

   e. i.



   ii. The net force in the vertical direction must be zero. Tension must support the weight

   iii. $\Theta = 20^{O}$

Universal Gravity

1. a. $2.05 \text{ X } 10^{22}$ N
   b. 3.56×10^{22} N
   c. 3.54×10^{22} N
2. a. 1.6 m/s^2
   b. 2.1 kg
   c. 20.58 N
   d. 3.36 N
3. a. $F_G = \frac{GM_Em}{a^2}$

   b. $a = \frac{GM}{r^2}$

   c. $g' = \frac{GM_E}{a^2}$, less than g on Earth

   d. $v = \sqrt{\frac{GM_E}{a}}$

   e. None

   f. $T = \frac{2\pi a}{\sqrt{\frac{GM_E}{a}}}$

4. a. 4.2×10^4 m/s

   b. $v = \sqrt{\frac{GM}{r}}$ if r increases and v decreases

   c. 1.1×10^4 s

   $r = 1.6 \times 10^8$ m

5. a. 0.21g

   b. 23.9 N

   c. 22.5 N

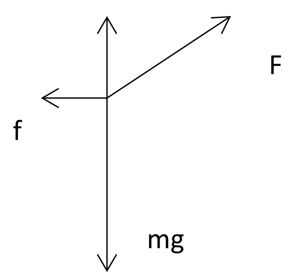
   d. F = 0

   e. 360 m

   f. 4.9 N

Energy

1. a.



   b. 447.2 J

   c. 0

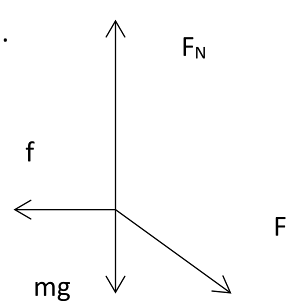
   d. 0

   e. -123.1 J

   f. 324.1 J

   g. 324.3 J

2. a.



   b. 974.3 J

   c. 0

   d. 0

e. -974.3 J
f. 0.47
g. 0

3. a. 190 J
b. 8.7 m/s
c. 190 m
d. 43.5 s
e. 190 J

4. a. $W = \frac{1}{2}KX^2$
b. $v = x\sqrt{\frac{K}{m}}$
c. $E_T = \frac{1}{2}KX^2 + mgH$
d. $t = \sqrt{\frac{2H}{g}}$
e. $r = x\sqrt{\frac{2KH}{mg}}$
f. $E_T = \frac{1}{2}KX^2 + mgH$

5. a. 200 J
b. 250 J
c. 10 m/s
d. 340 J
e. 340 J
f. 11.7 m/s

6. a. 40 m/s
b. 31.6 m/s
c. 37.4 m/s
d. 105, 000 N
e. 52, 440 N
f. 136 m

Momentum

1.
   a. 2.5 kg m/s
   b. 6.25 J
   c. 2.5 kg m/s
   d. 1.25 m/s
   e. 1.56 J
   f. 0.12 m
2. a. 0.3 kg m/s
   b. 2.25 J
   c. 0.3 kg m/s
   d. 0.33 m/s
   e. 0.05 J
   f. -2.2 J
   g. 0.006 m

3.
   a. 5 kg m/s
   b. 1250 J
   c. 3.3 m/s
   d. 8.2 J
   e. -1241 J
   f. 0.38 s
   g. 1.25 m

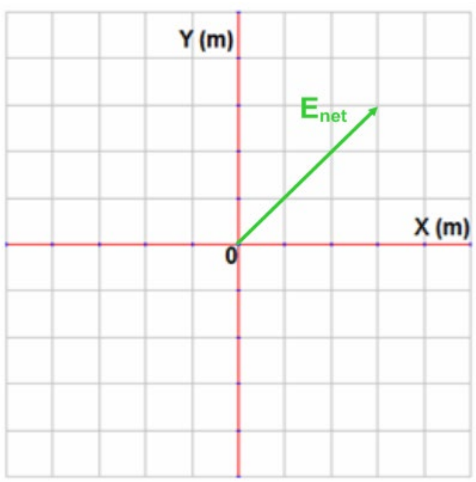
4.
   a. $(2gr)^{1/2}$
   b. $(2gr)^{1/2}/2$
   c. grm/2
   d. –mgr/2 (half is lost)
   e. r/4μ

5.
   a. 16 kg m/s
   b. 0
   c. 0
   d. 0
   e. 0
   f. 16 kg m/s
   g. 9.2 kg m/s
   h. 2.3 m/s
   i. -9.2 kg m/s
   j. 4.6 m/s

Electrostatics

1. a. 1.35×10^5 V
   b. 0.4 J
   c. 0.675 N
   d. 6 X 10 6 V/m
   e. 12.6 m/s

2. a. -2×10^{-5} C
   b. 6.48 N; Away
   c. 3.24 J
   d. -10.1×10^5 V
   e. 1×10^{-3} J
3. a. 0.052 N
   b.



   c. 13,000 N/C
   d. -0.26 J
   e. -9,000 V
   f. -9×10^{-6} J

4. a. 0
   b. $4\sqrt{(2)}$ kq/d
   c. $4\sqrt{(2)}$ kqq_O/d
   d. $\sqrt{(2)}$ $4kq/d^2$
   e. 0
   f. 0

5. a. Down
   b. 10,000 V/m
   c. 4.8 x 10^{-19-} C; must be negative
   d. 5 m/s^2

6. a. Up
   b. 2,400 V/m
   c. Parabolic, Downward
   d. 4.2 x 10^{14} m/s^2
   e. It will leave the plane

Electric Current and Circuits

1. a) Heating coils in parallel, voltmeter in parallel, ammeter in series.
   b) 1.3 A
   c) 11.35 V
   d) 14.9 W
   e) 4470 J

2. a) Two resistors in series with the motor. This reduces the currents to the required 0.5 A.
   b) 24 Ω
   c) 6 W

3. a) 288 Ω
   b) 50 W
   c) The power is less.
   d) 0.42 A
   e) 80 V
   f) 40 V

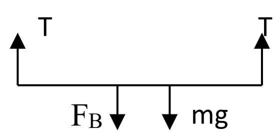
4. a) 24 Ω
   b) 0.6 V
   c) 0.15 A
   d) 6 V
   e) 1.5 W

5. a) 8 Ω
   b) 1.3 A
   c) 10.7 V
   d) 2.25 W
   e) 1.7 W

6. a) 6 Ω
   b) 3 A
   c) 1 A
   d) 27 μF
   e) 122 μJ

Magnetism

1. a. Out of the Page
   b. 4 x 10^{-3} T
   c. To the Right
   d.



   e. 1.3 N or .65 N each

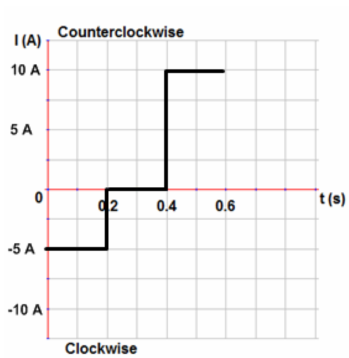
2. a. Positive
   b. $\sqrt{\frac{2gVa}{m}}$
   c. Down
   d. Circular
   e. $\frac{m}{gB}\sqrt{\frac{2gVa}{m}}$
   f. $\sqrt{\frac{2gVa}{m}}B$

3. a. Left
   b. 729 V
   c. Into the page
   d. 1.8 x 10^{-4} m
   e. Down
   f. 8 x 10^{6} N/C

4. a. Positive
   b. 3.5 x 10^{16} m/s^2
   c. 3.7 x 10^7 C/kg
   d. Right
   e. 4.7 x 10^7 V

Electro-Magnetic Induction

1.
   a. 0.2 Wb
   b.
      i. -1 V
      ii. 0
      iii. 2v
   c.
      i. 5 A
      ii. 0
      iii. 10 A
   d.



2.
   a. Counter clockwise
   b. 2 V
   c. 4 A
   d. 4 N
   e. 8 W
3.
   a. Counter clockwise
   b. ξ = BLv
   c. I = BLv/R
   d. E = Bv
   e. F = B^2L^2v/R
   f. P = $B^2L^2v^2/R$
4.
   a. 0.71 W
   b. 0.9 V
   c. 0.0841 A
   d. 0.0757 W