E 2

PHY 111 Kinetic Energy/Potential energy

1. What is the kinetic energy of a 1500-kg car with a velocity of 25 m/sec?

2. a) A 70-kg diver is standing 10 m above the water. What is his potential energy?

b) The diver jumps and gains speed as gets closer to the water. What is his potential energy just before he hits the water? (Answer: zero)

What is his kinetic energy just before he hits the water? (Answer: the same as the initial potential energy)

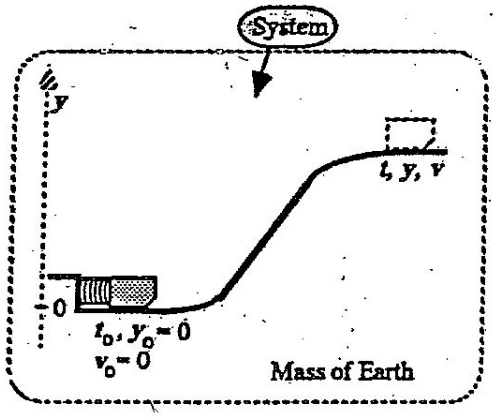
c) Knowing the diver's mass and kinetic energy, determine the diver's velocity just before he hits the water.

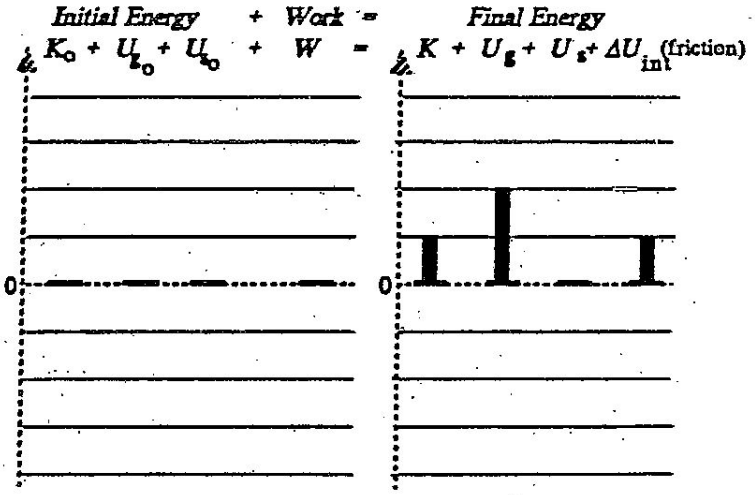
Note: the answer to c above is the same answer we would get using $d = \frac{1}{2}gt^2$.

2

PHY 111 Energy bar chart problems (#3)

Complete the energy bar chart then solve the problem.

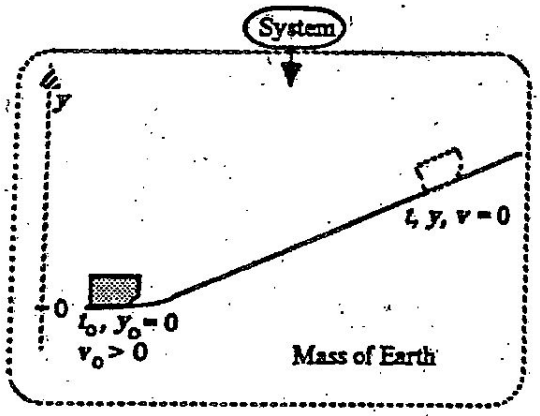


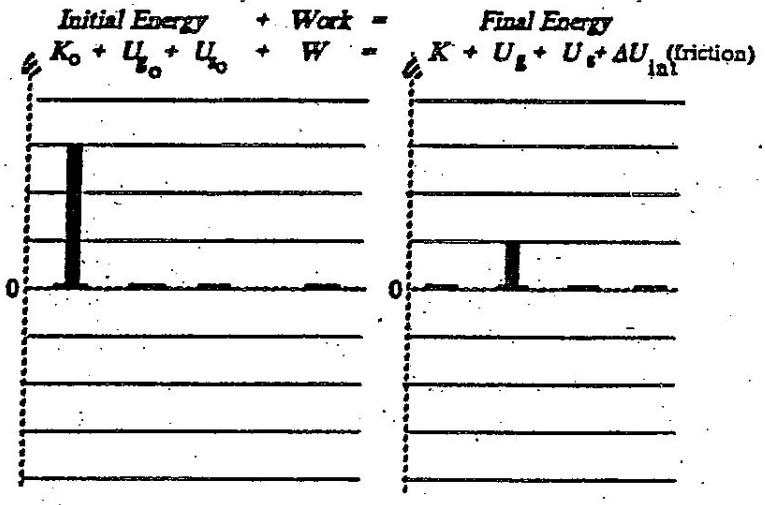


The spring is released and the .5-kg object is sent up the hill. At the level surface at the top of the hill the object has a velocity of 6 m/s. The top of the hill is 2 meters higher than the bottom. If 6 joules of heat are generated as the object slides up the hill, what is the initial potential energy stored in the spring?

PHY 111 **Energy bar chart problems (#4)**

Complete the energy bar chart then solve the problem.





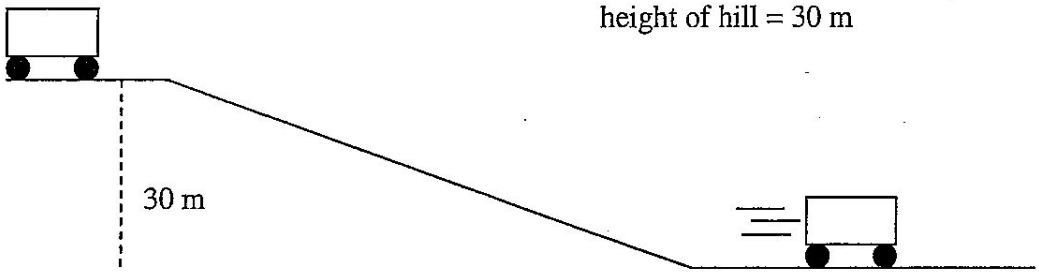
A 200-gram object (mass = ? kg) has an initial velocity of 3.5 m/s at the bottom of the hill. The object slides up to a point where the height y = 40 cm (? meters) before it comes to stop. How much friction heat is generated as the object slides up the hill?

4

PHY 111 A Car Rolling Downhill

mass of car = 1000 kg

height of hill = 30 m



1. A car is initially at rest at the top of a hill. It rolls down the hill without friction. Fill in the bar chart. Write an energy equation and find the velocity of the car at the bottom.

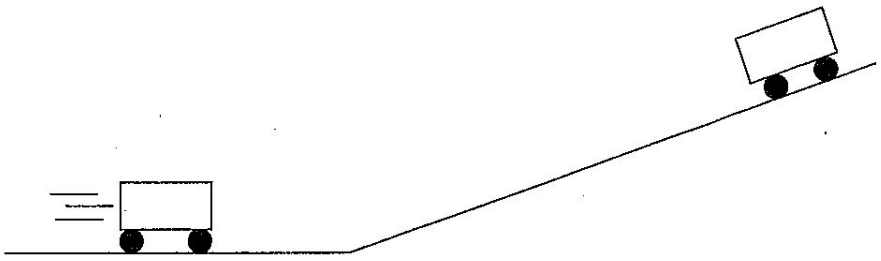
$K_o + U_{go} + U_{so} + \text{Work} = K_f + U_{gf} + U_{sf} + U_{int}$

2. A car is initially at rest at the top of a hill. Now suppose that half of the car's original potential energy is lost as friction as it goes down the hill. Fill in the bar chart. Write an energy equation and find the velocity of the car at the bottom.

$K_o + U_{go} + U_{so} + \text{Work} = K_f + U_{gf} + U_{sf} + U_{int}$

PHY 111 A Car Rolling Uphill

mass of car = 1000 kg



1. A car is initially rolling at the bottom of a hill with an initial velocity of 25 m/sec. It rolls up the hill without friction and without any other power. What vertical height y_f will the car reach before it comes to a stop? (Fill in the bar chart and write an energy equation.)

$K_o + U_{go} + U_{so} + \text{Work} = K_f + U_{gf} + U_{sf} + U_{int}$

If the hill makes an angle of 30° with the horizontal, what distance does it travel up along the hill?

2. The same car is rolling up the same hill, but this time there is a loss of 40% of the original energy as it travels up the hill due to friction. What vertical height y_f will the car reach before it comes to a stop? (Fill in the bar chart and write an energy equation.)

$K_o + U_{go} + U_{so} + \text{Work} = K_f + U_{gf} + U_{sf} + U_{int}$

If the hill makes an angle of 30° with the horizontal, what distance does it travel up along the hill?

6

PHY 111 Energy of a projectile

1. You throw a 500 gram ball upward with a velocity of 30 m/sec.
a) What is the kinetic energy of the ball as it leaves your hand?

b) Using conservation of energy, find the maximum height that the ball reaches. Assume your hand is at y = 0.

c) Find the maximum height of the ball using earlier methods.

2. A 145-g baseball is hit from a bat with a speed of 50 m/sec. The ball is caught by a fan in an upper deck 20 m above the playing field.
a) Do you expect that the speed of the ball when caught will be more than, less than, or equal to 50 m/sec? Explain your answer in terms of energy.

b) Find the speed of the ball when caught. (First fill in the energy bar chart.)

$K_o + U_{go} + U_{so} + \text{Work} = K_f + U_{gf} + U_{sf} + U_{int}$

_____ _____

PHY 111 Energy: Spring Launcher

A 100 gram object is initially inside a spring launcher. The spring is compressed and holds 8 J of spring potential energy.

a) The object is launched vertically upward. What is the speed of the ball the moment it leaves the launcher? (Ignore the small increase in gravitational potential energy as accelerates upward. while it is still in contact with the spring.)
(Fill in an energy bar chart.)

$K_o + U_{go} + U_{so} + \text{Work} = K_f + U_{gf} + U_{sf} + U_{int}$

_____ _____

b) What is the velocity of the ball at a height of 3 m above the launcher?
(Fill in an energy bar chart.)

$K_o + U_{go} + U_{so} + \text{Work} = K_f + U_{gf} + U_{sf} + U_{int}$

_____ _____

c) What is the maximum height of the ball?
(Fill in an energy bar chart.)

$K_o + U_{go} + U_{so} + \text{Work} = K_f + U_{gf} + U_{sf} + U_{int}$

_____ _____

8

PHY 111 **Projectile motion/energy**

A 5-kg cannon ball is loaded into a cannon with an amount of gun powder containing 20,000 J of chemical energy.

a) If 45% of the energy of the gun powder is transferred to the kinetic energy of the cannon ball, what is the speed of the cannon ball as it leaves the cannon?

b) If the barrel of the cannon is aimed at an angle of 30° above the horizontal, find the initial components of the velocity, v_x and v_y.

c) Find the maximum height of the cannon ball.

d) What is the velocity of the cannon ball at the top of its trajectory?

e) What are the kinetic energy and gravitational potential of the cannon ball at the top of its trajectory?

PHY 111 Doing work on a moving object

A 3-kg cart is coasting to the right at a speed of 4 m/sec. Assume there is no friction.

You now push the cart as it moves toward the right with a constant force of 10 N over a distance of 50 cm.

a) Will the cart gain speed or lose speed? Why?

b) Construct an energy bar chart for the process. The cart is in the system. You are outside the system.

$K_o + U_{go} + U_{so} + \text{Work} = K_f + U_{gf} + U_{sf} + \text{heat}$

c) What is the kinetic energy of the cart before you push? What is the kinetic energy of the cart after you push?

d) What is the speed of the cart after you push?

10

PHY 111 **Pushing a car up to Speed**

A man can push a car with a force of 800 N. Use an energy approach to calculate over what distance he would have to push a 1200-kg car to get it up to a speed of 4 m/sec.

a) Fill in the bar chart. Consider the man to be an outside force transferring energy to the car.

$K_o + U_{go} + U_{so} + \text{Work} = K_f + U_{gf} + U_{sf} + \text{Heat}$

b) Calculate the distance he would have to push the car.

c) How many joules of work did the man do? How many calories of energy is this? How many kilocalories (food calories) is this?

d) How many calories of food energy does the man need to consume if his body is 17% (1/6) efficient?

PHY 111 Work: Golf ball, Pushing a cart up a ramp

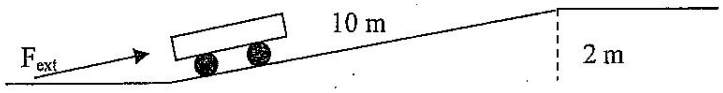
1. A golf ball has a mass of 50 g. The club head hits the ball with an average force of 1000 N. The head of the golf club is in contact with the ball for a distance of 20 cm.
(The ball is initially at rest. The golf club is an external force that does work on the golf ball.)

What is the velocity of the ball after being hit by the club?

$K_o + U_{go} + U_{so} + \text{Work} = K_f + U_{gf} + U_{sf} + U_{int}$

_____ _____

2. You want to push a 20 kg cart up a ramp. The ramp is 2 m high and 10 meters long. The initial speed of the cart at the bottom of the ramp is 1 m/s. The speed of the cart at the top of the ramp will also be 1 m/s. With what force do you have to push the cart up the ramp? Assume there is no friction between the cart and the floor. (Fill in the energy bar chart and solve for the force. The cart is in the system. You are outside the system. The force you exert on the cart is the external force F_{ext}.)



$K_o + U_{go} + U_{so} + \text{Work} = K_f + U_{gf} + U_{sf} + U_{int}$

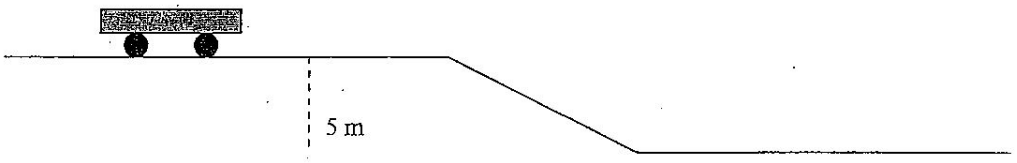
_____ _____

12

PHY 111 **Energy: Work and heat**

1. a) A 50 kg cart is coasting along the upper surface as shown on the diagram at a speed of 5 m/sec. While the cart is on the upper surface, the cart is given an extra forward push (in the direction of motion) of 200 N over a distance of 1.5 meter. The cart rolls down a ramp with a vertical altitude of 5 m on to a lower surface. What is the speed of the cart on the lower surface? Ignore friction. (First fill in the bar chart.)

Note: The extra forward push at the beginning is considered a force from outside the system.



$K_o + U_{go} + \text{Work} = K_f + U_{gf} + \text{Heat}$

_____ _____

b) Now suppose there is a force of friction on the bottom surface only where $\mu = .8$. How far will the cart roll before coming to a stop?

$K_o + U_{go} + U_{chem\,o} + \text{Work} = K_f + U_{gf} + U_{chem\,f} + U_{int}$

_____ _____

PHY 111 **Energy Problem**

Show all appropriate work.

At a center where passenger safety devices are tested for automobiles, cars are released from rest on an incline and allowed to roll into a concrete wall.

The mass of the car is 1100 kg. The length of the ramp is 20 meters. The distance along the level surface between the ramp and the wall is 10 meters. The angle of incline of the ramp is 12°. There is no friction on the car as it rolls down the ramp, but there is a force of friction of 1000 N on the car as it rolls along the level surface. What is the velocity of the car just before it hits the wall? (Fill in the bar chart, write the corresponding energy equation and solve for the unknown. You may let g = 10 m/s/s.)

Note: The heat generated is (*force of friction*)·(*distance*) .

$K_o + U_{go} + U_{so} + \text{Work} = K_f + U_{gf} + U_{sf} + \Delta U_{int}$

14

PHY 111 Power production

Three types of commercial power production are considered here. Assume each process is 80% efficient.

a) What is the power production of as hydroelectric plant in which that water falls a distance of 30 m and has a flow rate of 1 million liters per minute (1 liter of water = 1 1kg).

b) What is the power production of a power plant that burns coal at the rate of 50 tons per day? Coal contains 30 MJ (megajoules: mega means 1 million) of energy per kg. 1 ton is 1000 kg.

c) What is the power production of a solar power plant that has 1 square km of solar cells? (Sunlight has a power density of 1000 W/m^2) at the Earth's surface.)

PHY 111 **Energy to climb a mountain**

An average person (mass = 70 kg) climbs to the top of South Mountain (altitude 1100 feet*). How much energy is needed to lift the weight of that person from the bottom of the mountain to the top of the mountain in

* 1 foot is about 30 cm

joules?

calories?

kilocalories?

If it takes the person one hour to climb to the top, how many watts of power does the person generate? How many horsepower?

If it takes the person half an hour to climb to the top, how many watts of power does the person generate? How many horsepower?

Taking into account the energy efficiency of the average person (17%), what is the actual number of kilocalories the person must consume to reach the top of the mountain?

A 3.5-ounce container of Hunt's™ pudding contains 130 "calories". According to your calculations, how many pudding containers would the person have to eat to supply the energy to reach the top?

16

PHY 111 **Dragging Home a Christmas Tree**

You go out to the woods, you find a tree that would make a nice Christmas tree, cut it down and drag it home. The average force required to drag the tree is 50 N. The distance to your house is 1 mile or 1609 m.

Your pull on the tree is considered to be an external force doing work.

You can ignore the initial and final kinetic energy since that value would be very small compared to the total work being done and the speed of the tree is relatively small.

You are pulling the tree along a level surface so there is no change in potential energy.

a) How much work must you do to pull the tree home? Give answer in J, cal and kcal.

b) How many kcal of food must you consume in order to pull the tree home? (Assume your body is 1/6 efficient.)

c) If it takes 40 minutes to pull the tree home, at what rate is your body consuming energy in kcal/hour?

PHY 111 **Energy to load a trailer**

A worker has the job of loading a semi trailer with 30-lb. (13 kg) bags of insulation.

As each bag is picked up and carried onto the trailer, it will be lifted an average of 2.5 m higher than its original position on the ground.

The worker will load about 3 bags per minute for the next 90 minutes.

Not only does the worker have to carry up a bag every trip he makes into the trailer, but he must also lift himself (65 kg) a vertical distance of 1.5 m every time he walks up the ramp.

a) How many joules are needed to lift both the bag and the worker for every trip this is made into the trailer?

b) Express the energy from part a in calories and kilocalories?

c) How many kilocalories does the worker burn up in the 90 minutes of work?

d) A what rate is the worker burning energy in kcal/hr?

20

PHY 111 **Potential Energy of a spring**

1. A spring is attached to the ceiling. With no weights attached, its length is 10 cm. When a 2-kg mass is attached to the spring, its length is 15 cm.
a) What is the spring constant k?
b) How much energy is required to stretch the spring to that length?

2. A student places a 500 g book on a frictionless table. She pushes the book against the spring, compressing the spring by 4 cm, then releases the book. What is the book's speed as it slides away? The spring constant is 1250 N/m.

3. A 10-kg runaway shopping cart with a velocity of 5 m/sec runs into a spring with a spring constant 250 N/m. How far is the spring compressed?

PHY 111 Finding the horsepower for a car (#2)

Facts: 1 gallon of gasoline contains 1.3×10^8 J of chemical potential energy.

A gasoline engine under average conditions is about 25% efficient (25% of the gasoline's energy is used for moving the car.)

1 horsepower = 746 watts

<u>20 mpg at 70 mph</u>

a) At 70 mph, how many minutes does it take the car to use 1 gallon of gasoline? (Use the information to find hours/gallon.)

b) How much energy from that gallon of gasoline is used for moving the car? (Only 25% of the energy in the gallon of gas is used for moving the car.)

c) At what rate (in joules/sec) is energy being used for motion? Convert this rate to horsepower.