Name: ________________________________ Class: __________ Date: ___________

Sec 3 Physics

Worksheet 10: Work, energy and power

SECTION A: CONCEPTUAL QUESTIONS

1 How does friction produce internal energy? Explain what is happening at the molecular level to produce this form of energy.

2 Can the total work done on an object during a displacement be negative? Explain.

If the total work is negative, can its magnitude be greater than the object's initial kinetic energy? Explain.

3 An elevator is hoisted by its cables at a constant speed. Is the *total work* done on the elevator positive, negative or zero? Explain.

4 A rope tied to an object is pulled, causing the object to accelerate. According to Newton's Third Law, the object pulls back on the rope with equal and opposite force.

Is the net work done on the object zero?
Is there a change in the kinetic energy of the object?

5 When you use a jack to lift a car, the force you exert on the jack is much less than the car's weight. Does this mean that less work is done on the car than if the car is lifted directly?

6 A compressed spring is clamped in its compressed position and is then dissolved in acid. What becomes of the spring's elastic potential energy?

7 You bounce on a trampoline, going a little higher with each bounce. Explain how you increase your total mechanical energy.

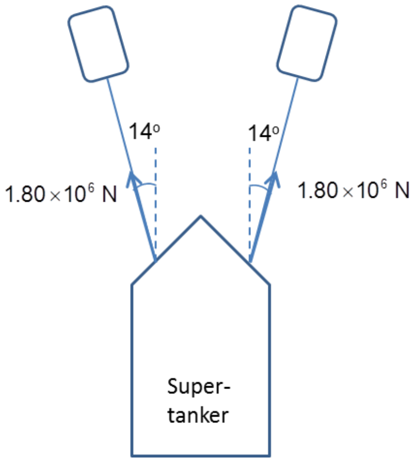
8 When you jump from the ground into the air, where does your kinetic energy come from? What force does work on you to lift you into the air?

9 Hydroelectric energy comes from gravity pulling down water through dams in rivers. Explain how such energy is just a form of solar energy by tracing how the sun's energy can get the water from the ocean to the reservoir behind the dam.

10 Does the kinetic energy of a car change more when the car speeds up from 10 km/h to 15 km/h or from 15 km/h to 20 km/h?

SECTION B: STRUCTURED QUESTIONS

1 Two tugboats pull a disabled supertanker. Each tug exerts a constant force of 1.80×10^6 N, one 14^o west of north and the other 14^o east of north, as they pulled the tanker 0.75 km toward the north. What is the total work they do on the supertanker?



2 The driver of an 1800 kg car (including passengers) travelling at 23 m s^{-1} slams on the brakes, locking the wheels on dry pavement. The total friction between the rubber wheels and the pavement is 1.2×10^4 N.

(a) Use the work-energy theorem to calculate how far the car will travel before stopping.

(b) How far would the car travel if it is moving twice as fast?

(c) What happened to the car's original kinetic energy?

3 About 50,000 years ago, a meteor crashed into the Earth near present-day Flagstaff, Arizona. Recent (2005) measurements estimate that this meteor has a mass of 1.4×10^8 kg and hits the Earth at 12 km s^{-1}.

a How much kinetic energy did this meteor deliver to the ground?

b How does this compare to the energy produced in one day by a standard coal-fired power plant, which generates about 1 billion joules per second?

4 A block of ice with a mass of 2.00 kg slides 0.750 m down an inclined plane. That slope is downward at an angle of 36.9° below the horizontal. If the block of ice starts from rest, what is its final speed? Ignore friction for this question.

5 To stretch a certain spring by 2.5 cm from its equilibrium position requires 8.0 J of work.

a What is the force constant of this spring?

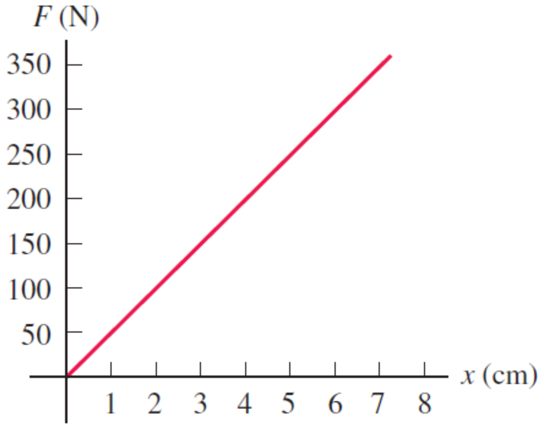
b What is the minimum force required to stretch it by that distance?

6 A spring of force constant 300.0 N m^{-1} and unstretched length 0.240 m is stretched by two equal and opposite forces of 15.0 N. *You may assume that the spring is very light.*

a What is the final length of the spring?

b How much work is needed to stretch the spring that distance?

7 The graph in the accompanying figure shows the magnitude of the force exerted by a given spring as a function of the distance x the spring is stretched. How much work is needed to stretch this spring:



a a distance of 5.0 cm, starting unstretched, and

b from x = 2.0 cm to x = 7.0 cm?

8 The *food calorie*, equal to 4186 J, measures how much energy is released when the body metabolizes food. A certain brand of the fruit-and-cereal bar contains 140 food calories per bar.

a Suppose a 65-kg hiker eats one of these bars. How high a mountain must he climb to work off the calories, assuming all the food energy goes only into increasing the gravitational potential energy?

b If, as typical, only 20% of the food calories go into mechanical energy, what would be the answer to part (a)?

Note: In this and all other problems, we assume that 100% of the food calories that are eaten are absorbed and used by the body. This is not true. A person's "metabolic efficiency" is the percentage of calories eaten used; the body eliminates the rest. Metabolic efficiency varies from person to person

9 Although the altitude may vary considerably, hailstones sometimes originate around 500 m above the ground.

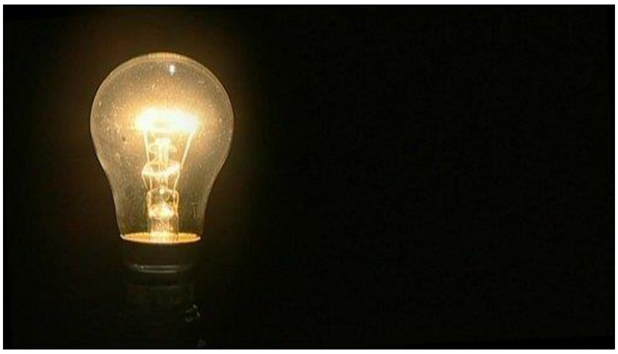
a Neglecting air drag, how fast will these hailstones be moving when they reach the ground, assuming that they started from rest?

b From your experience or intuition, are hailstones falling that fast when they reach the ground? Why not? What has happened to most of its initial potential energy?

10 **a** How many joules of energy does a 100-watt lightbulb use every hour?

b Express the answer in part (a) in terms of kilowatt-hour (kWh).

c The electrical tariff from Singapore Power from 1 Jul to 30 Sep is 23.38 cents per kWh. How much would it cost to operate the lightbulb for a full day?



"We will make electricity so cheap that only the rich will burn candles."
Thomas Edison, in a statement to a reporter during the first public demonstration of his incandescent (31 December 1879), as quoted in *Chronology of Americans and the Environment* (2011) by Chris J. Magoc, p. 46.

11 The sun transfers energy to the Earth by radiation at the rate of approximately 1.0 kW per m^2 of the surface.

a If this energy could be collected and converted into electrical energy with 25% efficiency, how large an area would be required to collect energy to be used in Singapore during the daylight hours?

Given that Singapore power consumption in 2008 is 37.11 billion kWh and assuming that power consumption is evenly spread throughout the year. You may assume that Singapore enjoys 12 hours of daylight a day.

b If the solar collectors are arranged in a square array, what would be its length in km? Does an array of these dimensions seem feasible?

3333 solar panels provided about 7% of the daily energy needs of Choa Chu Kang Waterworks.

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12 When its 75-kW engine is generating full power, a small single-engine airplane with mass 700 kg gains altitude at a rate of 2.5 ms^{-1}. What fraction of the engine power is being used to make the airplane climb? (The remainder is used to overcome the effects of air resistance and of inefficiencies in the propeller and engine.)

13 At the site of a wind farm in North Dakota, the average wind speed is 9.3 ms^{-1}, and the average density of air is 1.2 kgm^{-3}.

A Calculate how much kinetic energy the wind contains, per cubic metre, at this location.

B No wind turbine can capture all the energy contained in the wind, the main reason being that capturing all the energy would require stopping the wind completely, meaning that air will stop flowing through the turbine. Suppose a particular turbine has blades with a radius of 41 m and is able to capture 35% of the available wind energy. What would be the power output of this turbine, under average wind conditions?

14 A 75.0 kg mountain climber is holding his 60.0 kg partner over a cliff when he suddenly steps on frictionless ice at the horizontal top of the cliff, as shown in the accompanying figure. The rope has negligible mass and is held horizontally by the climber. There is no appreciable friction at the icy edge of the cliff. Use energy methods to calculate the speed of the climbers after the lower one has descended 1.50 m starting from rest.

15 **The spring of a spring gun has a force constant k = 400 N/m and negligible mass. The spring is compressed 6.00 cm and a ball with a mass of 0.0300 kg is placed in the horizontal barrel against the compressed spring. The spring is then released and the ball is propelled out of the barrel of the gun. The barrel is 6.00 cm long, so the ball leaves the barrel at the same point it loses contact with the spring. The gun is held so that the barrel is horizontal.

a Calculate the speed with which the ball leaves the barrel if you ignore friction.

b Calculate the speed of the ball as it leaves the barrel if a constant resisting force of 6.00 N acts on the ball as it moves along the barrel.

c For the situation in part (b), at what position along the barrel does the ball have the greatest speed, and what is that speed? (In this case, the maximum speed does not occur at the end of the barrel.)