

- 1) Bob pushes a 20 kg mass to the right 10 meters across a flat frictionless floor with a force of 80 N to the right. How much work does Bob do?
- 2) Minimally, how much work must a person do to lift a 5 kg mass to the third floor (4 meters per floor)?
- 3) Chris walks at a constant speed carrying a 50 N box across the floor at a height of 1.2 meters. He walks 8 meters. How much work does Chris do as he walks?
- 4) Sally pulls a 12 kg sled by a rope that is angled at 35° from the horizontal. She pulls with a force of 50 N for a total of 15 meters across frictionless ground. How much work does she do?
- 5) An engine is rated as 400 W. How much work does it do in 5 minutes?
- 6) A 2 kW motor is connected to a 400 kg mass. How long will it take to lift this mass by 10 meters at a constant speed?
- 7) A man is pushing a box at an average speed of 6 m/s across rough ground. To do this a 400 N force is required. What power is he developing?
- 8) Con Edison sells energy by the kilowatt-hour to homes. Each kilowatt-hour (this is a kilowatt times an hour) costs about 14.7 cents.
 - a) How many Joules are there in a kilowatt-hour?
 - b) If your home needs 1200 W of power for the day, how much will this cost?
- 9) A 30 N force acts towards the right on a 40 kg box initially at rest on a frictionless surface. In some interval of time, the box moves 25 meters as the force acts.
 - a) What is the work done by:
 - the applied force?
 - the weight?
 - the normal force?
 - b) Suppose a 10 N force also acts to the left during this time interval. What is the work done by the 10 N force?
 - c) What is the net work done?
 - d) What physical effect does this net amount of work have on the system? (i.e. what does this work actually do?)

10) Bobby is “working out” and doing bench presses. Let’s say he is benching 50 kg. He lifts the barbell 0.8 meters straight up. The barbell starts at rest and is at rest at the top of the motion.

- a) What is the weight of the barbell?
- b) What is the work done by gravity as the barbell goes up?
- c) What is the work done by gravity as he holds the barbell up at the top of his rep?
- d) What is the work done by gravity as he lowers the barbell?
- e) If he lifts with the minimum force needed to raise the barbell (which is the same magnitude as the weight), what is the work done by Bobby on the way up?
- f) What is the net work done on the way up?

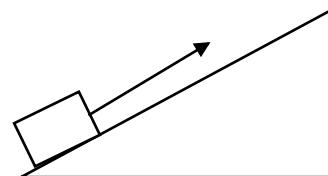
11) A 50 kg cart is initially moving at 5 m/s on flat ground. Friction brings it to rest after it moves 15 meters.

- a) What are the initial and final kinetic energies of the cart?
- b) What is the work done by friction?
- c) What is the magnitude of the frictional force?
- d) What is the coefficient of friction?

12) A 40 kg mass is pulled along level ground for 10 m by a 200 N force that acts at a 30 degree angle to the plane. The coefficient of kinetic friction is 0.2.

- a) Find the normal force.
- b) Find the frictional force
- c) Find the work done by
 - i. the applied force
 - ii. the weight
 - iii. the normal force
 - iv. the frictional force
- d) Find the net work done.
- e) IF the mass started at rest, find the final speed.

13) A couch is pushed up a frictionless ramp onto a truck as shown. The mass of the couch is 200 kg. A 2000N force is applied parallel to the plane. The ramp has an angle of inclination of 37° and the ramp is 4m long.



- a) Find the work done by the applied force
- b) Find the work done by gravity
- c) Find the work done by the normal force
- d) What is the net work done?
- e) What is final speed of the mass at the top of the ramp?

14) Redo problem 13 if the coefficient of friction is 0.20. (You will need to find the work done by friction)

15) Redo problem 13 if the plane were again frictionless but the 2000 N force were applied horizontally rather than parallel to the plane.

16) A 40 kg mass is on a flat frictionless plane. This mass is pulled to the right by Mike with a force of 150 N. Pauly pulls with a force of 80 N to the left. Both forces act over a displacement of 12 m to the right.

- a) What is the work done by Mike?
- b) What is the work done by Pauly?
- c) What is the work done by gravity?
- d) What is the work done by the normal force?
- e) If the mass started at rest, what is its speed at the end of the 12 meters

17) A 120 kg object is on a flat frictionless plane. Jenn pulls on this mass with a 200 N force acting up and to the left such that the force makes a 37° to the horizontal. She pulls over a distance of 15 m to the left.

- a) What is the normal force?
- b) What is the work done by the normal force?
- c) What is the work done by the weight?
- d) What is the work done by Jenn?
- e) If the mass is moving at 3 m/s to the left initially, what is the speed after 15 meters?

18) A boy lifts a 70 kg mass straight upwards. He exerts a 900 N force straight upwards on the mass such that the mass rises 2 meters upward.

- a) How much work does Ronnie's applied force do?
- b) How much work does gravity do?
- c) At the top of the 2 meters, what is the speed of the object?
- d) If Ronnie were to hold this mass over his head at a height of 2 meters for 10 seconds, how much work is he doing to hold the mass above his head?

Potential and Kinetic Energy Section

19) The 200 kg hammer of a pile driver is lifted 10 meters. Find the gravitational potential energy it has with respect to the ground.

20) A cannon shoots a 60 kg cannonball straight up so that it achieves a height of 400 meters.

- a) What is its gravitational potential energy at 400 meters?
- b) Once it reaches its maximum height, it falls. Calculate the change in the gravitational potential energy as it falls from 400 meters to 200 meters?

21) A person weighing 630 N climbs a ladder to a height of 5 meters.

- a) What is the person's increase in gravitational potential energy when they do this?
- b) What is the work done by the person to climb the ladder?

- 22) A cart is 20 kg and is initially moving at 15 m/s.
- a) What is the initial kinetic energy?
 - b) The person accelerates to 30 m/s (double the speed). What is the final kinetic energy?
 - c) By what factor did the kinetic energy change when the speed doubled?
 - d) How much work would be required to bring the cart from 0 m/s to 15 m/s?
 - e) How much work would be required to bring the cart from 15 m/s to 30 m/s?

Conservation of Energy Problems

23) A child and sled together that a combined mass of 50 kg are on the top of a frictionless hill. The child starts from rest at the top of the hill and has a speed of 12 m/s at the bottom of the hill. What was the height of the hill?

24) A 5 kg mass is initially traveling over flat frictionless ground at a speed of 4 m/s. It then begins going up a frictionless incline

- a) How much kinetic energy does the mass initially have?
- b) What is the total energy in the system initially?
- c) Does the total energy in the system change as the mass goes up the hill? Why or why not?
- d) Find the height on the hill when the mass stops instantaneously.
- e) How fast is the mass going when it has risen 0.5 meters?

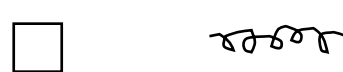
25) A 755N diver drops from rest from a diving board that is 10 meters above the surface of the water.

- a) Find the total energy in the system initially.
- b) What is the speed of the diver just as she enters the water?
- c) What is the speed of the diver when she is 5 meters above the water's surface?

26) A spring has a spring constant of 100 N/m and a natural length of 20 cm.

- a) If the spring is stretched to a total length of 30 cm, what is the tension in the spring? The potential energy stored?
- b) If the spring is compressed to a total length of 10 cm, what is the tension in the spring? The potential energy stored?

27) A 5 kg mass is moving with a velocity of 8 m/s across flat frictionless ground as shown. It strikes a spring that has a spring constant of 1000 N/m.



- a) What is the initial kinetic energy?
- b) How much does the spring compress?

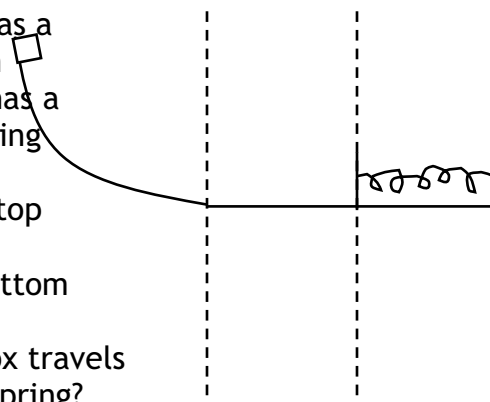
28) A 40 kg object is pressed up against a spring such that it is compressed 40 cm. The spring has a spring constant of 750 N/m. The ground is flat and frictionless.

- a) What is the initial energy stored by the spring?
- b) What is the speed of the mass once it leaves the spring?

29) Imagine now from the previous problem that the ground in front of the spring has friction with a coefficient of kinetic friction of 0.20. Eventually the mass slides until it comes to rest.

- What is the kinetic energy of the mass right as it leaves the spring? (feel free to cite info/work from the previous problem?)
- What is the force of friction the object experiences as it slides?
- When it comes to rest, what is the total energy of the system?
- What must have been the work done by friction?
- How far did the object slide until it came to rest?

30) A 20 kg box is at rest as shown to the right. No friction friction no friction
The arced ramp is a quarter of a circle that has a radius of 20 meters. The flat section between the hill and the spring is 20 meters long and has a coefficient of kinetic friction of 0.25. The spring has a spring constant of 2000 N/m



- Find the total energy of the system at the top of the hill.
- What is kinetic energy of the box at the bottom of the incline?
- What is the work done by friction as the box travels from the bottom of the incline to the spring?
- What is the total energy remaining in the system just before the box hits the spring?
- What will be the compression of the spring?