Work – Energy – Power

Work

- A force acting upon an object to cause
- Transfer of energy through
- Object has to
- Motion must be in the same direction as
- Work is a scalar quantity – only
- Work = F
- W =
- Units are
- Work can be positive or
  - +Work increases the energy of
  - -Work decreases the energy of
- Calculate the amount of work by the area under the curve of a Force –

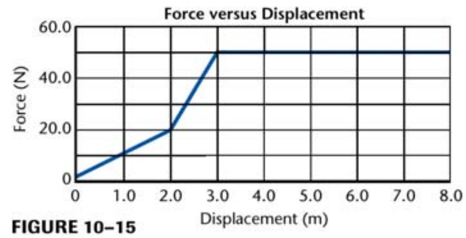

FIGURE 10–15

- Work?
  - Pushing against a wall until you are exhausted?
    - No –
  - A book falls off a table and free falls to the ground.
    - Yes – gravity does the work. Work is
  - A waiter carries a tray full of meals above his head by one arm across the room.
    - No! The force is not in the same direction as the motion. The only time the waiter does work is when
  - You are pulled down the street by your energetic dog on a leash.
    - Yes, but not all the force is being used to do work. Just the
    - $F_{horizontal}$ - Only part of the force pulling
  - Friction slows me down at the bottom of the bunny slope when I am ready for lunch on the cold spring day skiing.
    - Yes, friction is
  - I push a heavy box up a ramp.
    - Yes, I am "pushing" the
    - The distance up the ramp =
    - Work = (F_{net})
    - Work = (F_w)

Power

- Rate that
- How fast

-

-

- Units for power =
- 1 Hp (horsepower) =
- 1000 W = 1kW =

-

- Power = Force x

Machines
- Tool that makes the
- Changes the magnitude and/or
- DOES NOT change the work to
- Work = Force x
- No Machine With Machine

- *DOES NOT CHANGE THE WORK, DOES NOT CHANGE THE WORK, DOES NOT CHANGE THE WORK! NO NO WORK MUST BE DONE!*
- You sacrifice distance for an "easier" force. Apply a smaller force

Simple Machines
- *Levers* – a pivot point called a
  - ☐ Lever –
  - ☐ Wheel and axle –
  - ☐ Pulleys –
- *Classes of Levers*
  - ☐ 1st Class Lever – Fulcrum is between
  - ☐ 2nd Class Lever – Load is between the
  - ☐ 3rd Class Lever – Force is between the
- Inclined Plane –
  - ☐ Inclined Plane –
  - ☐ Wedge –
  - ☐ Screw –

Efficiency
- Most machines are not ideal, some energy is lost because

- Efficiency – how much work out you really get from the work

-

- Work in is greater than work out. Extra work “in” is the extra energy to overcome friction.
- Efficiency of a machine is 50% and you need 5kW of power, how much power must be
-
- Compound machine is two or more simple machines
- Efficiency (total) =
  ☐ Overall Efficiency
- Cars are about

1. After scoring a touchdown, an 84.0 kg wide receiver celebrates by leaping 120 cm off the ground. How much work was done in the celebration?

2. During a tug of war, the red team does 2.20×10^5 J of work pulling the white team 8.00 m. What force was the red team exerting?

3. A wagon is pulled by a force of 38.0 N on the handle at an angle of 42.0° with the horizontal. If the wagon is pulled in a circle of radius 25.0 m, how much work is done?

4. A 185 kg refrigerator is loaded into a moving van by pushing it up a 10.0 m ramp at an angle of inclination of 11.0°. How much work is done?

5. A 17.0 kg crate is to be pulled a distance of 20.0 m requiring 1210 J of work being done. If the job is done by attaching a rope and pulling with a force of 75.0 N, at what angle is the rope held?

6. An elevator lifts a total mass of 1100 kg, a distance of 40.0 m in 12.5 s. How much power does the elevator demonstrate?

7. A 1.00 x 10^3 kg elevator carries a maximum load of 8.00 x 10^2 kg. A constant frictional force of 4.00 x 10^3 N retards it motion upward. What minimum power, in kilowatts, must the motor deliver to lift the fully loaded elevator at a constant speed of 3.00 m/s? (64.8 kW)

Energy

Energy

- ***Energy*** – ability to produce a change to
  - Unit is
  -

Kinetic Energy

- ***Kinetic Energy*** – energy because the object is moving. Depends on the
  - K.E. =
  - Units are
  - Scalar Quantity –
  - Vibrational K.E. -
  - Rotational K.E. -
  - Translational K.E. –

Potential Energy

- ***Potential Energy*** -
  - Units are
  - Scalar Quantity –
  - ***Chemical Potential energy*** – energy stored in
  - ***Elastic potential energy*** – energy stored in
    - P.E. =
    - k =
    - x =
    - Hooke's Law – the force to stretch or compress a spring depends directly on the
    - F =
    - Springs with a high spring constant (k) are stiff.
    - Force is in the opposite direction as
    - Force is in the opposite direction of

- When the spring is stretched,
- When the spring is compressed,

- ***Gravitational Potential energy*** – energy because the object is above the reference (ground). Depends on the mass, acceleration due to gravity,
  - P.E. =

Mechanical Energy

- ***Mechanical Energy*** – energy of an object due to
  - Ability to do
  - An object with M.E. can use that energy to apply a force to another object
  - M.E. =

Work and Energy

- Work – transfer of energy by
- Work changes the potential and/or the
  - W =
  -
  -
  -
  -
  -
  -
  - W =
  - W =
  - W =
    - Work can change an object's
  - W =
    - Work can change an

8. What is the kinetic energy of a 3.2 kg pike swimming at 2.7 km/hr?

9. A force of 30.0 N pushes a 1.5 kg cart, initially at rest, a distance of 2.8 m along a frictionless surface.
   a. What work is done to the cart?
   b. What is cart's change in kinetic energy?
   c. What is the cart's final velocity?

10. A bike and rider, 82.0 kg combined mass, are traveling at 4.2 m/s. A constant force of 140 N is applied by the brakes in stopping the bike. What breaking distance is needed?

11. Each step of a ladder increases one's vertical height 40.0 cm. If a 90.0 kg painter climbs 8 steps of the ladder, what is the increase in potential energy?

12. A 0.25 kg ball is dropped from a height of 3.20 m and bounces to a height of 2.40 m. What is its loss in potential energy?

13. A 0.18 kg ball is placed on a compressing spring on the floor. The spring exerts an average force of 2.8 N through a distance of 15 cm as it shoots the ball upward. How high will the ball travel above the release spring?

14. A force of 14.0 N is applied to a 1.5 kg cart as it travels 2.6 m along an inclined plane. What is the angle of inclination of the plane?

Conservation of Energy

Systems

- **System** : a specific
- **Closed System**
  - ☐ Does not gain or lose mass;
  - ☐ Closed system has **Internal Forces**, but these do not change the
- **Isolated System**
  - ☐ The net external forces on a closed
  - ☐ No forces from the surroundings change the

Conservation of Energy

- The amount of energy in an closed, isolated system can change form, but the total amount of energy
- M.E. before =
- ΣK.E. + ΣP.E. =
- Kinetic energy can be converted into
- Potential energy can be converted into

Work-Energy Theorem

- The total amount of mechanical energy plus the work done by external forces is equal to the final
- Work can be
- ΣK.E. + ΣP.E. + W =

15. In an electronics factory small cabinets slide down a 30.0° incline a distance of 16.0 m to reach the next assembly stage. The cabinets have a mass of 10.0 kg each. Calculate the velocity each cabinet would acquire if the incline were frictionless.

16. An average force of 8.2 N is used to pull a 0.40 kg rock stretching a sling shot 43 cm. The rock is shot downward from a bridge 18 m above a stream. What will be the velocity of the rock just before it enters the water?

17. A scale with a spring constant of 420 N/m is compressed 4.3 cm. What is the spring force? What is the potential energy?

18. A 68 kg weight is attached to a giant spring and it stretches 6.5 cm. What is the spring constant?

19. The launching mechanism of a toy gun consists of a spring of unknown spring constant. If the spring is compressed a distance of 0.120 m and the gun fired vertically, the gun can launch a 20.0 g projectile from rest to a maximum height of 20.0 m above the starting point of the projectile. Neglecting all resistive forces, calculate:
   a. the spring constant
   b. the speed of the projectile as it moves through the equilibrium position of the spring.

20. A skier, mass 50.0 kg, is at the top of a ski slope that is 50.0 m above the ski lodge. She skies down the hill and up the next hill, which is 20.0 m high. How fast is she going over the small hill?

21. On the next run, a friend bumps into her at the top of the first hill, giving her a skiing start of 10.0 m/s. How fast is she going over the top of the small hill?

22. A beginner skier (mass 50.0 kg), inspired by the first skier, goes down and up the next hill. She is a beginner, so she snow plows (as all beginners do). I estimate the snowplowing crates around 8,250 J of friction (and you though only the sun melts the snow). How fast is she going over the small hill? No one bumps her because she would fall down and make a sitz mark for you to fall into!

23. Water slides are nearly frictionless, hence can provide bored students with high speed thrills. One such slide, Der Stuka, named for the terrifying German dive bombers of World War II, is 72.0 feet high (21.9 m), found at Wet'n Wild in Orlando, Florida.

   a. Determine the velocity of a woman at the bottom of such slide, assuming no friction is present.
   b. If the woman (mass 60.0 kg) is clocked at 18.0 m/s at the bottom of the slide, how much mechanical energy was lost through friction?

24. A powerful grasshopper launches itself at an angle of 45° above the horizontal and rises to a maximum height of 1.00 m during the leap. With what initial velocity did it leave the ground? Neglect air resistance.