14.1: Work and Power
What is Work?

• An object begins to move only when an unbalanced force acts on it.

• **Work** = product of the **force** applied and the **distance** the object moves.

• Work is done when a force acts on an object in the direction the object moves.
  – EX: work is done by a weightlifter when he exerts an upward force to raise the barbell over his head.
Work Requires Motion

• For a force to do work on an object, some of the force must act in the same direction as the object moves.
• If there is no movement, no work is done.
Question?

- Is the weightlifter doing work? Why or why not?
  - No...force is being applied to the barbell but the barbell is NOT moving.
    - Work was done while the barbell was being lifted.
Work Depends on Direction

• The amount of work done, if any, depends on the direction of the force and the direction of the movement.
  – Force does not have to act entirely in the direction of movement to do work.

• Any part of a force that does not act in the direction of motion does no work on an object.
Question?

• Look at Figure 2 A,B & C...in which picture(s) is work being done?

• Describe the relationship between the force applied and the direction the suitcase is moving.
  – A: force and motion are in the same direction, work is being done.
  – B: horizontal force is responsible for movement because the suitcase is moving in that direction, work is being done.
  – C: vertical (lifting) force, lady is picking the suitcase up, but the suitcase is not moving in that direction...work is not being done.
Calculating Work

Work

Formula: \( W = f \cdot d \)

Units: Work = Joules (J)
Force = Newton (N)
Distance = meters (m)
Practice Calculating Work

1. A weight lifter raises a 1600-newton barbell to a height of 2.0 meters. How much work is done?
Calculating Work

• A weight lifter raises a 1600-newton barbell to a height of 2.0 meters.
  • Work = Force × Distance
  • Work = 1600 N × 2.0 m
Calculating Work

• A weight lifter raises a 1600-newton barbell to a height of 2.0 meters.

  • Work = Force × Distance
  • Work = 1600 N × 2.0 m
  • Work = 3200 N·m = 3200 J
Calculating Work

2. A girl lifts a 160-N load a height of 1 m in a time of 0.5 s. How much work is she doing?
Calculating Work

3. Sally applies 53N force to move her bed 5m, how much work did she do?
Calculating Work

4. How much work is required to lift 63N 12m high?
What is Power?

• The rate of doing work.
  – How fast work is completed.

• Doing work at a faster rate requires more power.
  – To increase power, you can increase the amount of work done in a given time, or you can do a given amount of work in less time.
Question?

- Look at Figure 3 on page 414...
  - Are both people in the pictures doing work?
  - Which person will be finished with their work first? Why?
  - Which tool, the shovel or the snow blower, has more power?
Calculating Power

**Formula:**  \[ P = \frac{W}{T} = fd \]

**Units:**
- Power = watt (W)
- Work = Joules (J)
- Time = Seconds (s)
Calculating Power

1. How much power is needed to do 552 Joules of work in 107 seconds?
Calculating Power

2. You exert a vertical force of 72 newtons to lift a box to a height of 1.0 meter in a time of 2.0 seconds. How much power is used to lift the box?

\[
\text{Power} = \frac{\text{Work}}{\text{Time}} = \frac{\text{Force} \times \text{Distance}}{\text{Time}}
\]
Calculating Power

• You exert a vertical force of 72 newtons to lift a box to a height of 1.0 meter in a time of 2.0 seconds. How much power is used to lift the box?

\[
\text{Power} = \frac{\text{Work}}{\text{Time}} = \frac{\text{Force} \times \text{Distance}}{\text{Time}}
\]

\[
\text{Power} = \frac{72 \text{ N} \times 1.0 \text{ m}}{2.0 \text{ s}} = 36 \text{ J/s} = 36 \text{ W}
\]
3. Your family is moving to a new apartment. While lifting a box 1.5 m straight up to put it on a truck, you exert an upward force of 200 N for 1.0 s. How much power is required to do this?
Calculating Power

1. Your family is moving to a new apartment. While lifting a box 1.5 m straight up to put it on a truck, you exert an upward force of 200 N for 1.0 s. How much power is required to do this?

Answer: Work = Force × Distance =

\[ 200 \text{ N} \times 1.5 \text{ m} = 300 \text{ J} \]

Power = Work/Time = 300 J/1.0 s = 300 W
Calculating Power

4. You lift a book from the floor to a bookshelf 1.0 m above the ground. How much power is used if the upward force is 15.0 N and you do the work in 2.0 s?
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Answer: Work = Force × Distance =
15 N × 1.0 m = 15 J
Power = Work/Time = 15 J/2.0 s = 7.5 W