THE ERINDALE ACADEMY
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Unit 2: Work and Momentum
Lesson 1: Work, Kinetic Energy, Gravitational potential energy

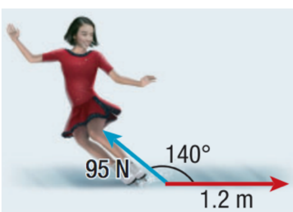
Part I: Work (Chapter 4.1)

Work: Depends on the magnitude of the force applied to an object and the distance the object moves. If the force vector falls towards the direction of displacement, that work is doing a positive work, and vice versa.

Formula: $\boldsymbol{W = \vec{F} \cdot \vec{d} = F\Delta d cos\theta}$

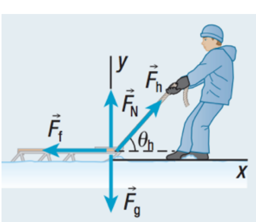
Question: When does the force do ZERO work? Does the centripetal force in circular motion do zero work?

Example 1:
An ice skater slides to a stop by pushing her blades against the ice. The ice exerts a constant force of 95 N on the skater, and the skater stops in 1.2m. The angle between the force and the skater's direction of motion is 140°. Calculate the work done on the skater by the ice.



Practice: Textbook pg 167. #1, 2, 3

Example 2: Calculating the work done by multiple forces on a dragged object.
The hiker exerts a constant force of 135N on the sled at a 48.0° angle to the sled's displacement. At the same time, a constant 67.0 N frictional force on the sled from the snow opposes the motion. The sled also experiences the force from gravity and the normal force from the snow, but these forces do not contribute to the work. Calculate the total work done on the sled when the hiker pulls the sled 345 m over the snow.



Practice: Textbook pg170. #1, 4, 5, 6

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Part II: Kinetic Energy (Chapter 4.2)

$$W = F_T \Delta d$$
$$W = ma\Delta d$$
$$v^2 = v_i^2 + 2a\Delta d$$
$$v^2 = v_i^2 + 2a(d_f - d_i)$$
$$a(d_f - d_i) = \frac{v_f^2 - v_i^2}{2}$$
$$W = ma(d_f - d_i) = m\frac{v_f^2 - v_i^2}{2}$$
$$W = \frac{1}{2}mv_f^2 - \frac{1}{2}mv_i^2$$

Kinetic Energy: The energy an object possesses due to its motion.

Formula: $E_k = \frac{1}{2}mv^2$, hence: heavier the mass or faster the velocity, greater the E_k.

Question: is that possible of the kinetic energy of a jet bigger than the kinetic energy of a bird? Why?

Work-Energy Theorem: Newton's second law of motion indicates that when an object is subjected to a net external force, it accelerates in the same direction as the force. This motion results in work being done on the object. Hence, when the object's speed changes due to this acceleration, then its kinetic energy also changes.

Hence, $W_{total} = F_{net} \cdot \Delta d = \Delta E_k = E_{kf} - E_{fi} = \frac{1}{2}mv_f^2 - \frac{1}{2}mv_i^2$

Example 3:
A shuffleboard player wants to slide a 430 g disc a distance of precisely 12 m. If the coefficient of kinetic friction between the disc and the playing surface is 0.62, calculate the initial speed at which the player must release the disc.

Practice: Textbook pg176. #1, 4, 5, 8, 10

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Part III: Gravitational potential Energy

Gravitational potential Energy:

- E_g is a kind of stored energy as a result of the gravitational force between the object and the surface of Earth.
- As we lifted the object away from the surface, it causes an increase in elevation. The height above the ground makes the object has the potential to drop, or the potential to pick up kinetic energy from the force of gravity after we release it.
- This potential to increase kinetic energy is a form of stored energy. The stored energy that an object has that can be released into another form of energy is potential energy.

Figure 2 A worker applies a force F_a to a crate, doing work as he lifts the crate from the ground up to the truck bed. The change in height of the crate is Δy.

$$W = F\Delta d\cos\theta$$
$$= F\Delta y\cos\theta$$
$$= mg\Delta y(\cos 0°)$$

$$W = mg\Delta y$$

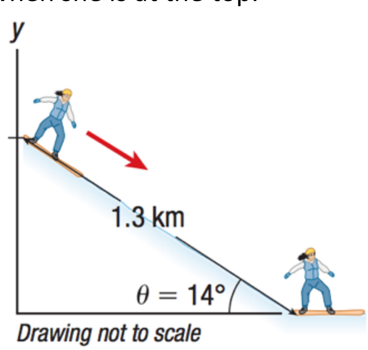
$$\Delta E_g = mg\Delta y$$

Many other forms of potential energy:

- A long-jumper poised to jump has potential energy stored in his muscles.
- A stretched elastic band has elastic potential energy to shoot target off by converting into kinetic energy

Mechanical energy = Gravitational potential energy + Kinetic energy

Example 4: A 59 kg snowboarder descends a 1.3 km ski hill from the top of a mountain to the base. The slope is at an angle of 14° to the horizontal. Determine snowboarder's gravitational potential energy relative to the mountain base when she is at the top.



Practice: Textbook pg181. #1 – 6