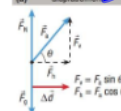## SPH3U 5.1 Work

1. Work done by a constant force

Mechanical work:	a force applied over a distance.
equation	$W = F \Delta d \cos \theta$ Units: J (Joules).
theta	θ is the angle between F and Δd
special case	$\theta = 0$. in this case, $W = F \Delta d$

How much mechanical work does a person do on a shopping cart if they apply a force of 25 N in the forward direction, and displace the cart 3.5 m in the same direction?

$$W = F \Delta d \cos \theta$$
$$= 25 (3.5) \cos 0$$
$$= 88 J.$$

A curler applies a force of 15.0 N on a curling stone and accelerates the stone from rest to a speed of 8.00 m/s in 3.50 s. Assuming that the ice surface is level and frictionless, how much mechanical work does the curler do on the stone?

$$W = F \Delta d. \qquad \Delta d = ? \qquad v_i = 0, \; v_F = 8.00, \; \Delta t = 3.50s.$$

$$\Delta d = \left(\frac{v_i + v_F}{2} \right) \Delta t = \left(\frac{0 + 8}{2} \right) (3.5) = 14.0m.$$

$$W = F \Delta d = 15(14) = 2.10 \times 10^2 \, J.$$

2. Work done when force and displacement are in different directions

Calculate the mechanical work done by a custodian on a vacuum cleaner if the custodian exerts an applied force of 50.0 N on the vacuum hose and the hose makes a 30.0° angle with the floor. The vacuum cleaner moves 3.00 m to the right on a level, flat surface.

$$W = F \Delta d \cos \theta = (50)(3) \cos 30°$$
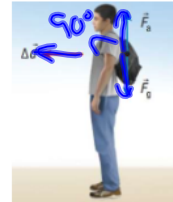$$= 1.30 \times 10^2 J.$$

3. Special cases

Ranbir wears his backpack as he walks forward in a straight hallway. He walks at a constant velocity of 0.8 m/s for a distance of 12 m. How much mechanical work does Ranbir do on his backpack?

$$W = F \Delta d \cos\theta = F_A (12) \cos 90° \qquad \cos 90° = 0.$$
$$= 0 J.$$

How much mechanical work is done on a stationary car if a student pushing with a 300 N force fails to displace the car?

$$W = F \Delta d \cos\theta \qquad \Delta d = 0. \qquad \therefore W = 0 J$$

A shopper pushes a shopping cart on a horizontal surface with a horizontal applied force of 41.0 N for 11.0 m. The cart experiences a force of friction of 35.0 N. Calculate the total mechanical work done on the shopping cart.

Shopper:
$$W = F \Delta d \cos\theta$$
$$= 41(11)\cos 0$$
$$F_f \longleftarrow \boxed{} \longrightarrow F_A = 451 J.$$

Friction:
$$W = F \Delta d \cos\theta$$
$$= 35(11)\cos 180°$$
$$= -385 J.$$
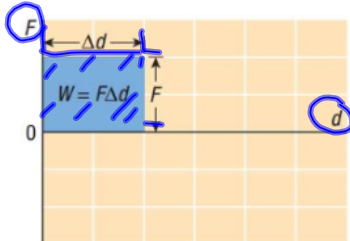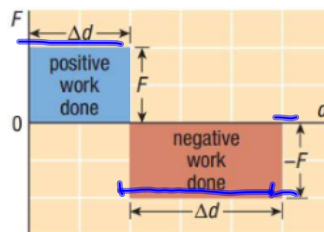
Total:
$$W_s + W_f = 451 - 385$$
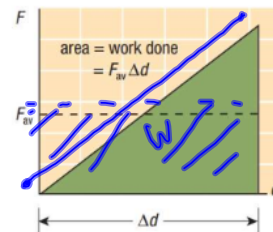$$W_{net} = 66 J.$$

F is changing

4. Graphing work done

$$W = \text{area under the curve!}$$
$$W = b \times h$$

When F is negative, the area is negative!

$$W = F_{av} \Delta d.$$

$$W = \frac{1}{2}bh$$
$$W = F_{av} \Delta d.$$

Homework: page 229:   #1-3, 5-6, 9