Unit 3: Circular Motion, Work and Energy

3.5 Work

Which person is doing more work?

or

More mass

or

higher → more d

weight lifter on the Moon or weight lifter on the Earth

Fg is bigger

$$W = \Delta E$$

Work is a change in energy...but this is saying a lot more than it seems.

From the previous slide, we can deduce that:

work is proportional to mass

$W \propto m$

work is proportional to displacement

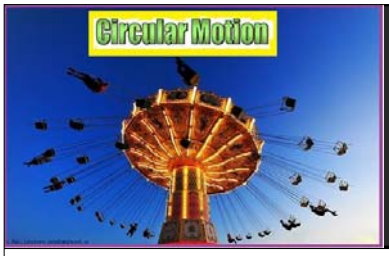
$W \propto \vec{d}$

work is proportional to acceleration (ie. gravity)

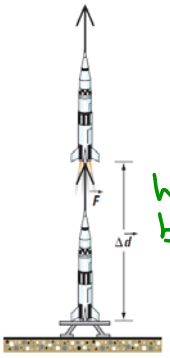
$W \propto \vec{a}$

F = ma

So... $W = \vec{F} \cdot \vec{d}$



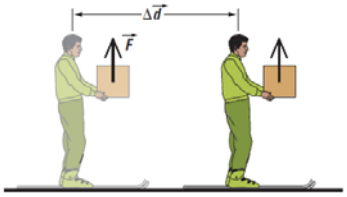
Work is scalar (only a magnitude). However, force and displacement must be in the same direction for work to have been done!!



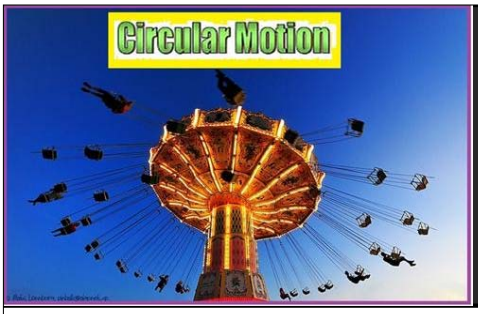
Work is being done.

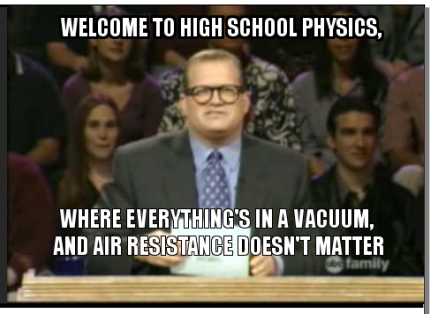
▲ Figure 6.6

No work being done



▲ Figure 6.7





Ex.) How much work is done in lifting a 25 kg box to a height of 5 m?

$W = Fd$

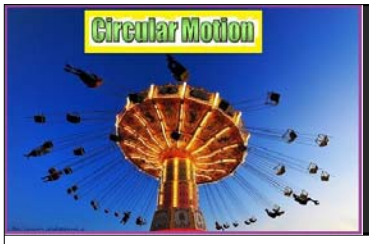
$= mad$

$= (25)(9.81)(5)$

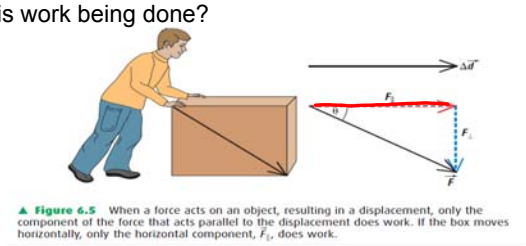
$= \boxed{1.2 \times 10^3 \text{ J}}$

Ex.) How much work is needed, after lifting the box to carry it horizontally 250 m?

0 J



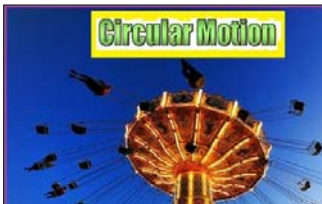
What about this fella...there are two dimensions to the force he is applying to the box so is work being done?



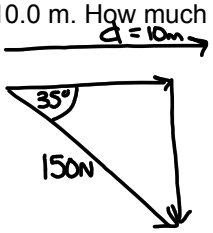
▲ **Figure 6.5** When a force acts on an object, resulting in a displacement, only the component of the force that acts parallel to the displacement does work. If the box moves horizontally, only the horizontal component, $\vec{F}_{\parallel}$, does work.

The answer is yes...sort of. When force is being applied at an angle, θ, we can break the force down into parallel and perpendicular components. Therefore, if one component of the force is acting in the same direction as the displacement, some work is being done. We can find it using our old pal, Trigonometry.

$$W = |\vec{F}|\,|\vec{d}|\cos\theta$$



Ex.) Ryan is shoveling the walk. A force of 150 N is applied down the shovel handle, which makes an angle of 35.0° with the horizontal. Ryan pushes the shovel 10.0 m. How much work is being done on the shovel?



$W = Fd\cos\theta$

$= (150)(10.0)\cos 35°$

$= 1.23 \times 10^3\ J$

$\cos 35° = \frac{F_H}{150}$

$150\cos 35° = F_H$

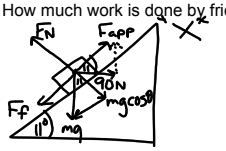
**units for work are Joules

Ex.) A 7.0 kg crate is pushed up a hill with an incline of 11.0° for 3.00 m. A 90 N horizontal force, parallel to the ground, is applied to the crate. The coefficient due to friction is 0.200.

a) How much work is done?

b) How much work is done by gravity against the crate?

c) How much work is done by friction against the crate?



a) $F_{app} = \frac{90}{\cos 11°} = 92\,N$

$\cos 11° = \frac{90}{F_{app}}$

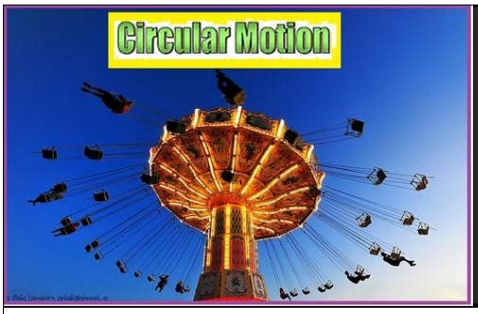
$W = Fd$
$= (92)(3)$
$= 2.8 \times 10^2\,J$

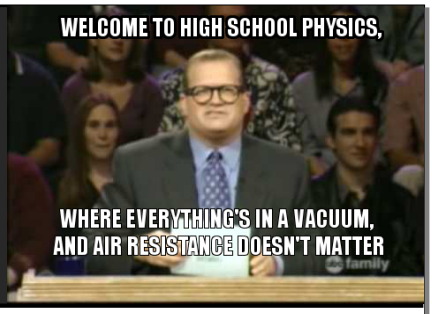
b)

$\sin 11° = \frac{h}{3}$ $h = 0.572...\,m$

$W = F_g \cdot h = mgh$
$= (7.0)(9.81)(0.572)$
$= 39\,J$

c) $W = F_f \cdot d$
$= \mu mg\cos\theta d$
$= (0.200)(7.0)(9.81)\cos 11°(3)$
$= 40\,J$





Read: Pg. 293-294.

Questions: Pg. 294 Practice Problems.