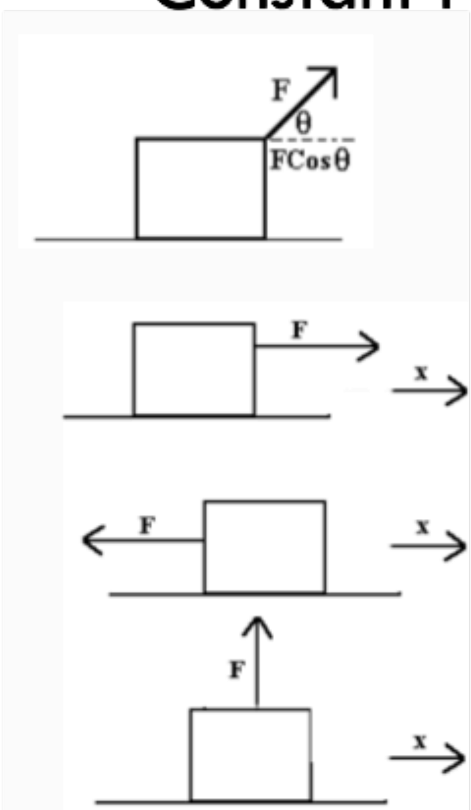
Work done by a Constant Force

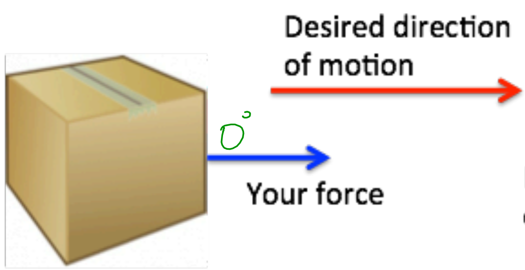


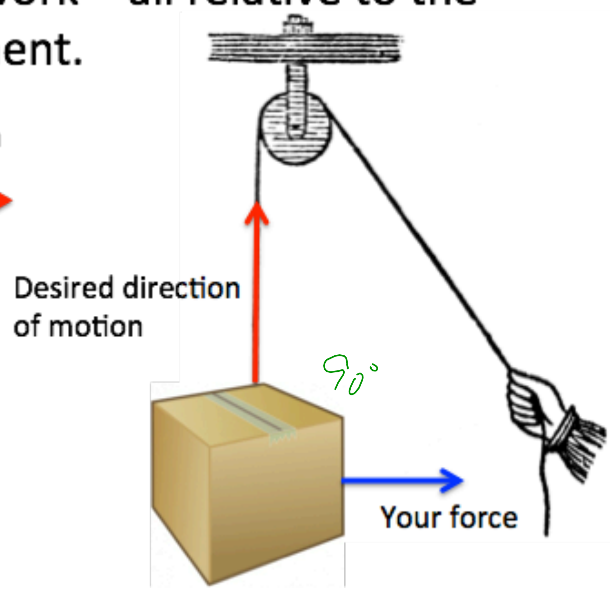
Work - Summary

- **Important to note** – What is the direction of movement.
  - Cosθ is the angle between the force in question and the movement of the object
- **Most effective:** Cosθ = 0^o
  - (Forces that are parallel to movement)
- **Most In-effective:** Cosθ = 90^o or 270^o = work done is 0
  - (Forces that are perpendicular to movement)

Positive or Negative or Zero

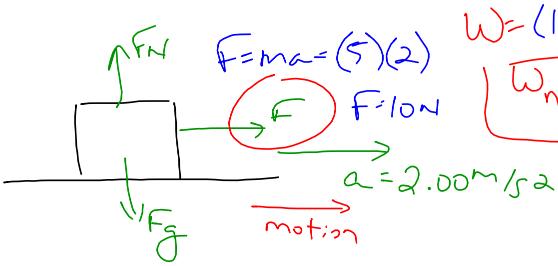
- Positive, negative, or zero work – all relative to the desired direction of movement.





Example 1

A box of mass 5.00 kg is accelerated from rest across a smooth, frictionless surface at a rate of 2.00 m/s^2 for 7.00 s. Find the net work done on the box.



$F = ma = (5)(2)$

$F = 10\text{ N}$

$W = F^* \cdot d \cdot \cos\theta$

$W = (10)(49)\cos 0°$

$W_{net} = 490\text{ J}$

$t = 7.00\text{ s}$

$a = 2.00\text{ m/s}^2$

$V_0 = 0\text{ m/s}$

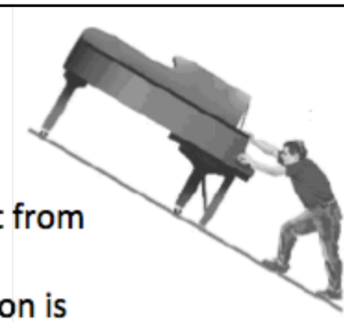
$d = x =$

$x = x_0 + v_0 t + \frac{1}{2}at^2$

$x = 0 + (0)(7) + \frac{1}{2}(2)(7)^2$

$x = d = 49\text{ m}$

Example 2



A 330.0 kg piano slides 3.60 m down a 28.0° incline and is kept from accelerating by a man who is pushing back on it parallel to the incline. See the figure provided. The coefficient of kinetic friction is 0.40. Please do the following

Equilibrium or Non-equilibrium ΣF_x: $\Sigma F_x = 0$

Equilibrium or Non-equilibrium ΣF_y: $\Sigma F_y = 0$

A. Draw the FBD and the tilted FBD

B. Calculate the force applied the by man needed to keep the piano from accelerating.

C. Calculate the work done by the force from the man.

D. Calculate the work done by the force of friction.

E. Calculate the work done by the force of gravity (which component of gravity can actually do any work?)

F. Calculate the work done by the normal force.

G. Calculate the net amount of work done.

Net Work done by a Constant Force

Looking at the net amount of work.....

Positive amount of net work relates to an **increase** in energy

Negative amount of net work relates to a **decrease** in energy

Zero amount of net work relates to **no change** in energy

Example 3

A 2.00 kg ball is attached to a 0.80 m string and whirled in a horizontal circle at a constant speed of 6.00 m/s. The work done by the force of tension on the ball during each revolution is...

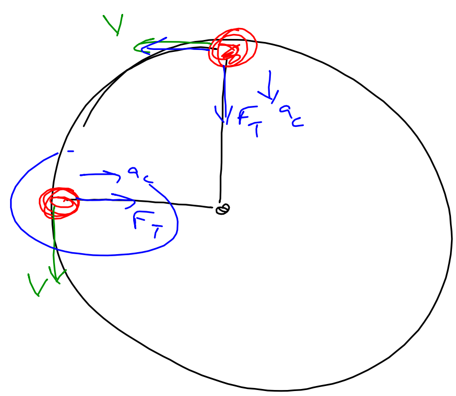
A. 450 J

B. 90 J

C. 72 J

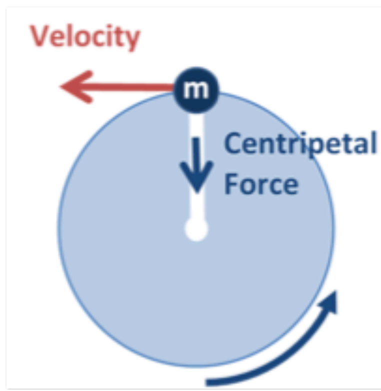
D. 16 J

E. Zero



Work done by Centripetal Forces

Consider an over-head view of the scenario mentioned in example 3...



- The centripetal force provided by the string is always 90^o away from the direction of movement.
- In addition, any additional forces from F_g or F_N (if this object was supported on a table of some kind) are also 90^o away from the direction of movement

Example 4

A force F directed at an angle θ above the horizontal is used to pull a crate a distance D across a level floor. The work done by force F is...

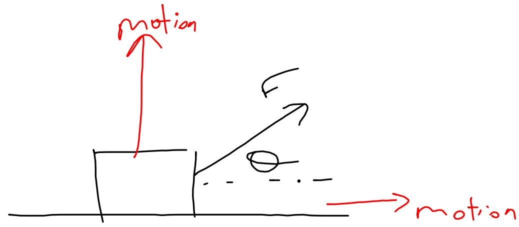
A. FD

B. FD cosθ

C. FD sinθ

D. mg sinθ

E. mgD cosθ



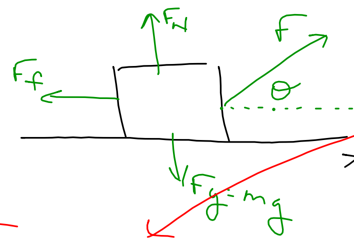
$W = F \cdot D \cdot \cos\theta$

Example 5

A force at an angle θ above the horizontal is used to pull a heavy suitcase of weight mg a distance d along a level floor at a constant velocity. The coefficient of friction between the floor and the suitcase is μ. The work done by the frictional force is:

A. $-Fd\cos\theta$
B. $mgh - Fd\cos\theta$
C. $-\mu Fd\cos\theta$
D. $-\mu mgd$
E. $-\mu mgd\cos\theta$

$*W = F \cdot d \cdot \cos\theta$



$\Sigma F_x = F_x - F_f$

$0 = F_x - F_f$

$F_f = F_x$

$* \; * F_f = F \cdot \cos\theta$

$\Sigma F_y = F_N + F_y - F_g$

$0 = F_N + F_y - F_g$

$F_f = \mu_k \cdot F_N$

$W = F_f \cdot d \cos\theta$

$W = F \cdot \cos\theta \cdot d \cdot \cos 180°$

$W = F \cdot d \cdot \cos\theta(-1)$

Power

- Power (P) is the **efficiency** of a force
  - Rate at which work is done

$$*P = \frac{W}{t} = \frac{J}{s}$$

$P \cdot t = W$

- SI Unit: Watts (W)

Watt. J/s

Work → J

① P = 10 W unit

② W = 22 J variable

*Beware: Work (W) and Watts (W)

* Assumption θ = cos 0° = 1

$$*P = \frac{W}{t} = \frac{F \cdot d}{t} = *F \cdot \bar{v}$$