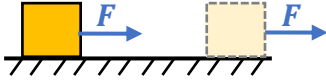


CONCEPT: WORK DONE BY A CONSTANT FORCE

- When you push an object (box) at rest with constant force along a smooth horizontal surface, it starts to move!

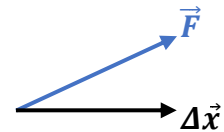


- It gains speed (v), so it gains _____ Energy. This Energy comes from _____!

- WORK (W)** is the _____ of Energy transferred between objects. You “_____” on the box. Unit: [____]

$W_F = \text{_____} = \text{_____}$

, where θ is always the angle between ____ & ____.
(Work done by Constant Force)



EXAMPLE: You pull a 2kg box initially at rest horizontally with 3N. Calculate the work you do on the box if you pull it a distance of 5m.

EXAMPLE: A 5kg cart is moving to the right at 10m/s when a 100N stopping force to the left acts on it over a distance of 2.5m. Calculate the work done by this stopping force.

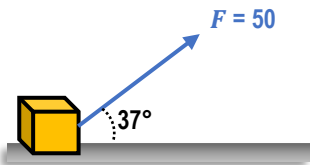
- W is the amount of Energy any force **gives to** (___W) or **takes away** (___W) from the object.
 - If the force “helps”, i.e goes along with the object’s motion, the work done is [**POSITIVE** | **NEGATIVE**]
 - If the force “hurts”, i.e goes against the object’s motion, the work done is [**POSITIVE** | **NEGATIVE**]

PROBLEM: You pull a 5kg box vertically up with a constant 100N force for 2m. How much work do you do?

- A) 51 J
- B) 100 J
- C) 102 J
- D) 200 J
- E) 500 J
- F) 1000 J

WORK & ENERGY
$KE = \frac{1}{2}mv^2$
$W = Fd\cos\theta$

PROBLEM: You pull a 10kg suitcase with a 50 N force angled 37° above the floor. You pull the suitcase for 20m. **a)** Find the Work done by your pull $\mathbf{F}$. Decompose $\mathbf{F}$ into $\mathbf{F}_x$ and $\mathbf{F}_y$ and calculate the work done by **b)** $\mathbf{F}_x$ and **c)** $\mathbf{F}_y$.



PROBLEM: A box weighing 50N rests on a smooth, flat surface. The coefficient of kinetic friction $\mu_k = 0.7$. You pull the box horizontally with 60 N for 8m. Calculate the work done by **a)** Kinetic Friction; **b)** Weight; **c)** Normal.



- Friction always **opposes** motion ($\vec{v}$) so it *ALWAYS* does _____ WORK:

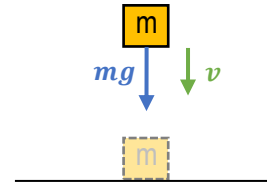
$$W_{f_k} = f_k d \cos(___) = ______$$

CONCEPT: WORK DONE BY GRAVITY

- Because gravity is a FORCE (mg), gravity can also DO WORK.
 - Remember: Work is a transfer of energy $\rightarrow$ positive when F is along motion, negative when F is against motion.

Object Falling (Going Down)

EXAMPLE: A 5.1kg book falls from a 2m-tall bookshelf. The book has a speed of 6.26 m/s when it hits the ground. **a)** Calculate the work done on the book by gravity. **b)** Calculate the book's kinetic energy right before hitting the ground.



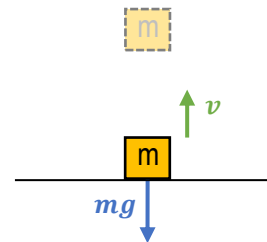
• $W_g = Fd\cos\theta = (\text{ })(\text{ })\cos(\text{ }) = \text{ }$

- Gravity does [+ | -] Work

$W_g = \text{ }$

Object Rising (Going Up)

EXAMPLE: You throw a 2kg rock vertically upwards with an initial velocity of 15m/s. The rock rises to a max height of 11.5m. **a)** Calculate the initial kinetic energy of the rock. **b)** Calculate the work done on the rock by gravity.

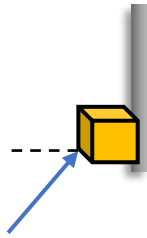


• $W_g = Fd\cos\theta = (\text{ })(\text{ })\cos(\text{ }) = \text{ }$

- Gravity does [+ | -] Work

PROBLEM: You push a 3k box against a wall for a distance of 2m with a force of 40N that makes a 53° angle with the horizontal, as shown. Calculate the work done by gravity.

- A) 58.8 J
- B) - 58.8 J
- C) - 160 J
- D) - 80 J



PROBLEM: A 75 kg hiker starts at the bottom of a 1,000 m mountain, and hikes up to the top. The hiker takes an irregular path with varying speeds & inclinations. How much work does gravity do on the hiker during the entire hike?

- Work done by Gravity depends ONLY on the change in _____, *not* the path taken. This is called **path independence**.