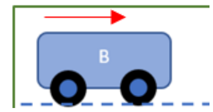
ENGR 110 PAL Worksheet #8

Force "Cumulative Effect"(*Use g = 9.81 m/s² = 32.2 ft/s²*)

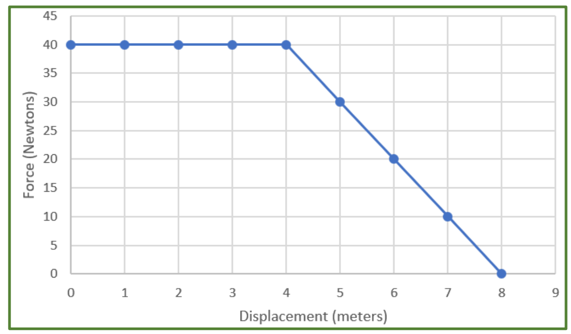
Here are two main ways to quantify the effect of a force that acts for a bit:

A. Work (W). If you know the *displacement* over which a force acts, you can find the associated work W. Also, it's always true that the net Work on an object is equal to that object's *change in kinetic energy*. ***net W = ΔKE***.

- ✓ SI units of work are Newton-meters.
- ✓ 8 Newton-meters of work is equivalent to a 8 Newton force acting over 1 meter (or a 1 Newton force acting over 8 meters).



1. In each case, find the 100 kg cart's KE once the work is complete. The cart moves initially at 10 meters/sec to the right (positive direction).
   a) 100 Newton-meters of positive work is done on the cart.
   b) A force of 50 Newtons to the left acts over a displacement of 8 meters.
   c) Work is done by the variable force graphed to the right. The y-axis is in Newtons, the x axis in meters.

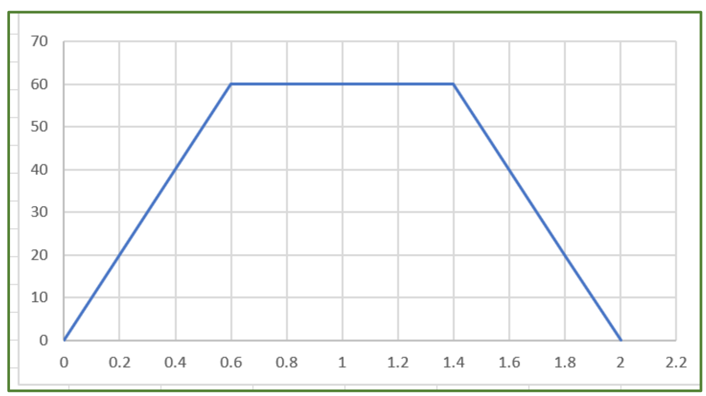


2. In each case determine the net work on the object.
   a) mass = 4 kg, initially at rest, final velocity = 20 meters/sec
   b) mass = 20 slugs, initial velocity = + 15 ft/sec, comes to rest.
   c) mass = 40 kg, initial velocity = + 10 meters/sec, final velocity = -10 meters/sec.

B. Impulse (I). A force's impulse on an object is the product of the force and the time (duration). **I = Favg*Δt**.

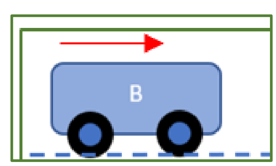
- ✓ SI units of impulse are Newton-seconds. A 10 Newton-second is equivalent to a 10 Newton force acting for 1 second (or a 1 Newton force acting for 10 seconds).
- ✓ Impulse is a vector (it has direction).
- ✓ If the force is variable, you have to do some averaging or use Calculus (i.e. integration).

4. Find the impulse associated with
   a) a 10 pound force acting in the positive direction for 8 seconds
   b) a 100 Newton force acting in the negative direction for 5 seconds
   c) a 10 kN force acting south for 4 seconds
   d) the variable force graphed to the right. x-axis is seconds, y-axis Newtons.

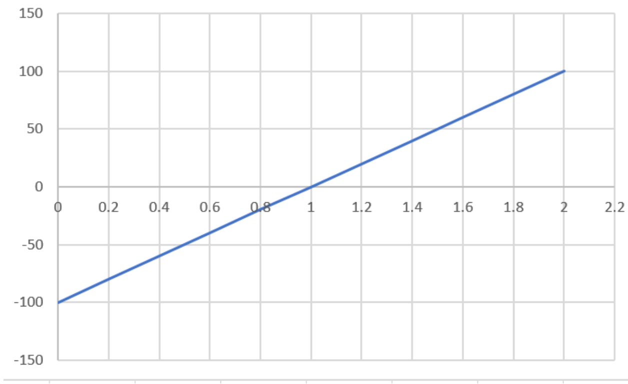


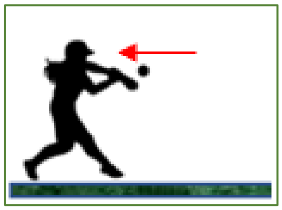
The net Impulse on an object is always equal to that object's *change in momentum*. **net I = $p_{final} - p_{initial}$.**

5. In each case, find the 100 kg cart's momentum once the impulse is complete. The cart moves initially at 10 meters/sec to the right (positive direction).
   a) A 50 N*sec impulse to the right acts on the car.
   b) A force of 100 N Newtons to the left acts for 20 seconds.



c) Impulse on the cart is per the graph; x-axis in seconds, y-axis in Newtons.

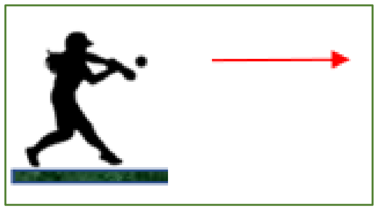




6. Fast-pitch softball! The 0.644 pound softball approaches the batter at speed 60 mph.

a) Determine the softball momentum in slug*ft/sec before the batter hits it. Suggestions: Make right the positive direction and use the conversion 1 mile = 5280 ft.

The batter makes solid contact, sending the ball to the right at 90 mph.



b) Determine the impulse of the bat on the ball (magnitude and direction). Answer in lb*secs.

c) Time-lapse photography shows that the contact time between the bat and the ball is 0.001 seconds. Determine the average force of the bat on the ball (magnitude and direction). Answer in pounds.

d) Determine the average force of the ball on the bat (magnitude and direction).

e) * During contact, the force of the bat on the ball varies roughly as indicated in the graph below; the x-axis is in seconds. The force increases rapidly, then is basically a constant maximum value, and then decreases as the ball loses contact with the bat. Determine the maximum force during contact in pounds.