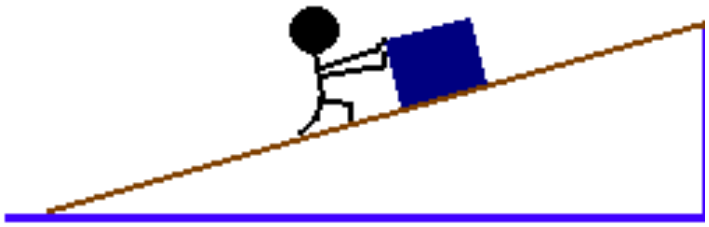
Physic² 121:
Phundament°ls of Phy²ics I

Friday the 13th of October, 2006

Bob and the Ramp

- Bob is pushing a crate up a ramp. He exerts a force of 100 N on the crate. The crate has a mass of 10 kg. The ramp is at an angle of 30°, and the coefficient of kinetic friction between the ramp and the box is 0.2.
- Q: What is the acceleration of the crate?



Momentum

Chapter 6

N2 and Acceleration Definition

- Remember Newton's 2nd Law?

$$\vec{a} = \frac{\vec{F}_{Net}}{m}$$

- And the definition of average acceleration?

$$\bar{a} = \frac{\Delta v}{\Delta t}$$

- Combining these two ideas we get:

$$F = ma$$
$$= m\frac{\Delta v}{\Delta t}$$

- Or:

$$F\Delta t = m\Delta v$$
$$= m\left(v_f - v_i\right)$$

Impulse and Momentum

- The things on the left and right side of the equal sign each have their own name in the world of physics:
  - $F\Delta t$ is called Impulse, I
  - mv is called momentum
  - Momentum usually denoted as p

$$\vec{I} = \vec{F}\Delta t$$

$$\vec{p} = m\vec{v}$$

- So, we can write the last equation from previous slide as:

$$\vec{I} = \Delta\vec{p}$$

- Note: This is really just N2 written in a different way

Units

- Units of momentum:
  - $p = mv$, so $[p] = M\ L\ /\ T$
  - In SI units, kg m / s
  - No special name
- Units of Impulse
  - $I = F\Delta t$, so $[I] = (M\ L\ /\ T^2)xT = M\ L\ /\ T$
  - In SI units, kg m / s (note: same dimensions as momentum!)
  - Again, no special name

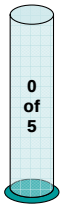
?

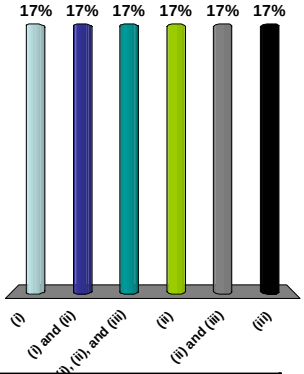
Consider these situations:

(i) a ball moving at speed v is brought to rest
(ii) the same ball is projected from rest so that it moves at speed v
(iii) the same ball moving at speed v is brought to rest and then projected backward to its original speed

In which case(s) does the ball undergo the largest change in momentum?

1. (i)
2. (i) and (ii)
3. (i), (ii), and (iii)
4. (ii)
5. (ii) and (iii)
6. (iii)





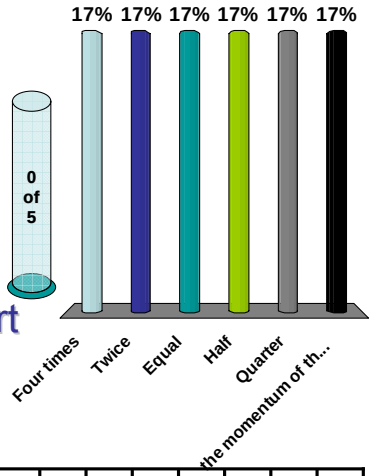
1	2	3	4	5														

?

Consider two carts, of masses m and 2m, at rest on an air track. If you push first one cart for 3s and then the other for the same length of time, exerting equal force on each, the momentum of the light cart is:

1. Four times
2. Twice
3. Equal
4. Half
5. Quarter

the momentum of the heavy cart



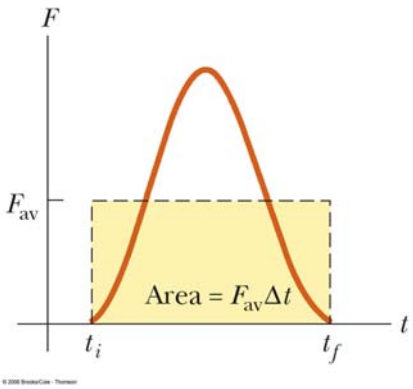
1	2	3	4	5														

Impulse-Momentum Theorem

- The theorem states that the impulse acting on the object is equal to the change in momentum of the object
  - $\vec{\mathbf{F}}\Delta t = \Delta\vec{\mathbf{p}} = m\vec{\mathbf{v}}_f - m\vec{\mathbf{v}}_i$
  - If the force is not constant, use the *average force* applied

Average Force in Impulse

- The average force can be thought of as the constant force that would give the same impulse to the object in the time interval as the actual time-varying force gives in the interval



Average Force cont.

- The impulse imparted by a force during the time interval Δt is equal to the area under the force-time graph from the beginning to the end of the time interval
- Or, the impulse is equal to the average force multiplied by the time interval,

$$\vec{\mathbf{F}}_{av}\Delta t = \Delta\vec{\mathbf{p}}$$

Impulse Applied to Auto Collisions

- The most important factor is the collision time or the time it takes the person to come to a rest
  - This will reduce the chance of dying in a car crash
- Ways to increase the time
  - Seat belts
  - Air bags

Air Bags

- The air bag increases the time of the collision
- It will also absorb some of the energy from the body
- It will spread out the area of contact
  - decreases the pressure
  - helps prevent penetration wounds