Physics In Hockey

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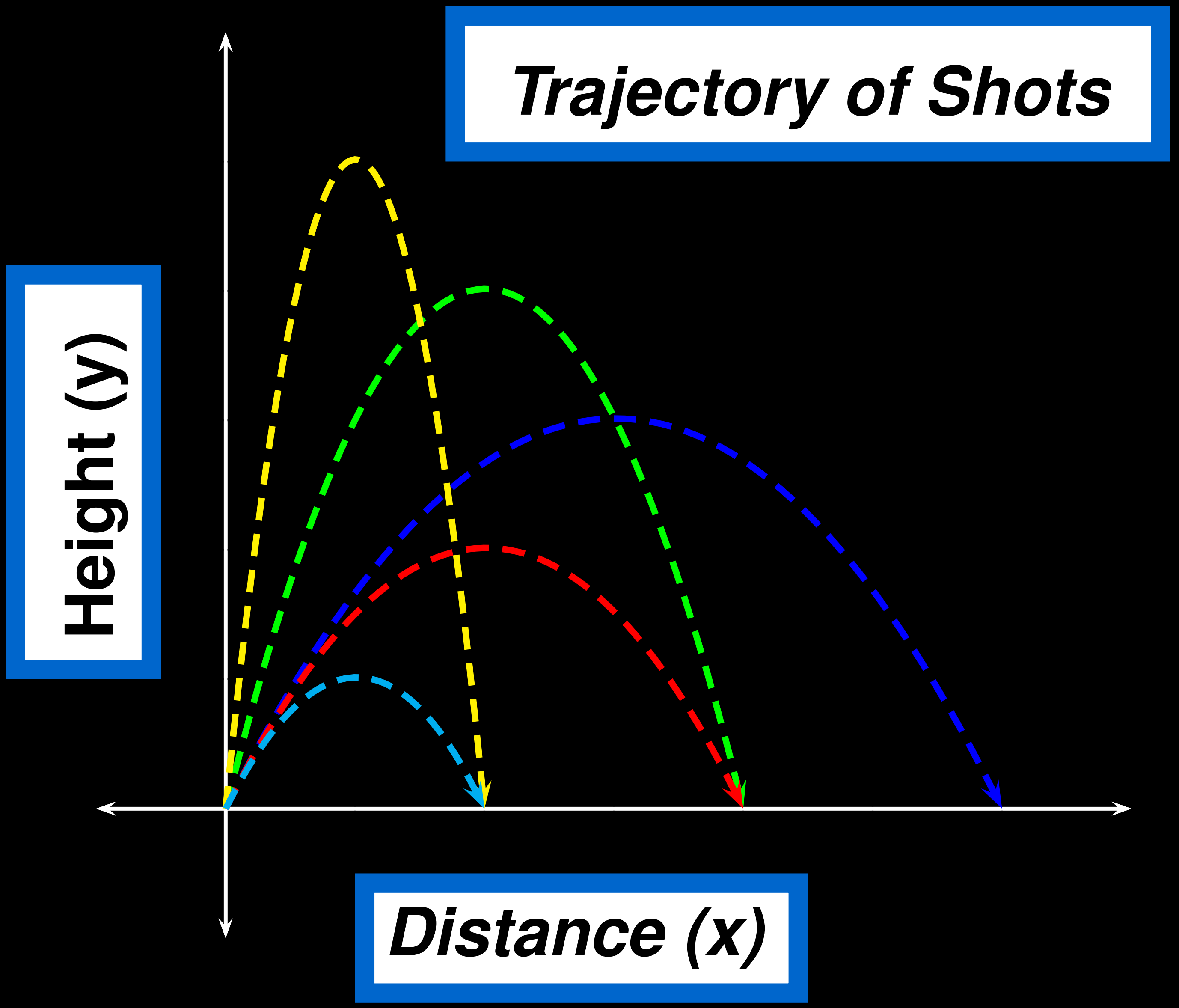
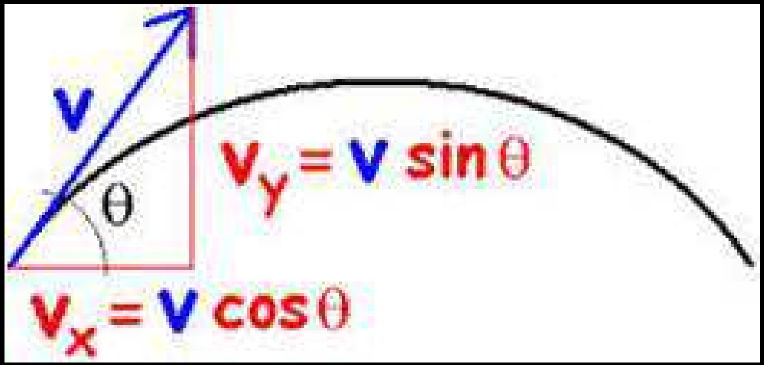
Projectile Motion



Projectile Motion

The projectile motion for shooting a hockey puck can be pictured in a two dimensional form

- x-direction represents horizontal movements
- $V cos(\theta)$ defines the magnitude in x direction
- y-direction represents vertical movements
- $V sin(\theta)$ defines the magnitude in y direction
- Movement up and to the right is positive just like in any standard math graph



Variables

In projectile motion, there are many variables that effect the trajectory of the shot These variables include:

- Velocity Initial
- Velocity Final
- Angle or Direction
- Acceleration
- Time

$$Velocity = \frac{\Delta(distance)}{\Delta(time)}\ \ in\ \ a\ \ specific\ \ direction$$

$$Magnitude = Velocity\ @\ \theta^{\circ}$$

- Velocity Initial is the player's magnitude plus the magnitude of the shot
- Velocity Final is the puck's magnitude after a defined period of time or distance

Angle and Types of Shots

Effects of Angles:

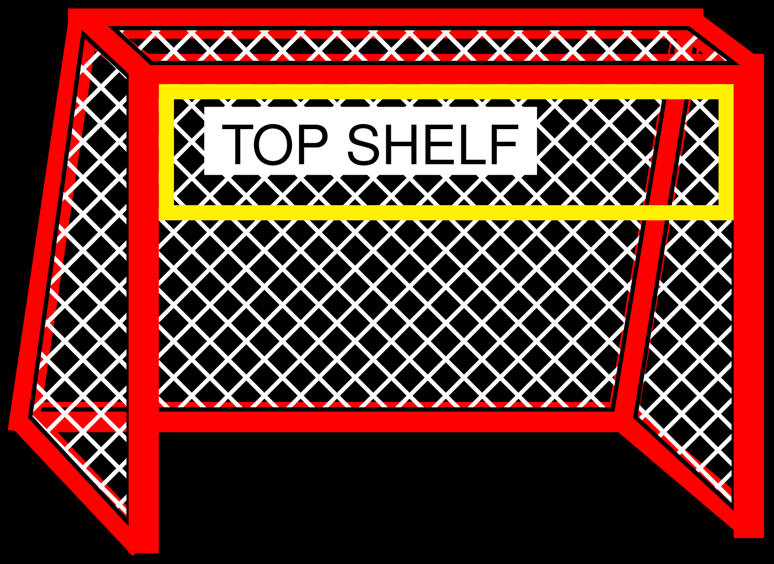
- The angle that the puck is released at determines height and distance
- Shots released at different angles have varying advantages.

Ranges of Angles:

- Shallow angles (0°- 30°) travel low heights and small distances in the air
- Moderate angles (30°- 60°) travel medium heights and cover large distances in the air
- Steep angles (60°- 90°) travel to high heights and small distances in the air

3 main types of shots:

1. Chip Shot:
   - Chip Shots range in the steep angle category
   - Chip Shots are used to score *TOP SHELF* over a laying down goalie
   - Chip Shots are quick and take the least amount of time to release but do not reach high velocities



Types of Shots Cont'd

2. Slap Shot:

- Slap Shots typically range in the shallow angle category
- Slap Shots are generally the highest velocity shot and are used mostly by defense-men
- Slap Shots take more time to release and therefore are not as versatile

3. Wrist/Snap Shot:

- Wrist/Snap Shots typically range in the moderate angle category
- The ideal shot to get the most distance in the air would be a wrist/snap shot
- Wrist/Snap Shots reach medium velocities and are relatively quick and accurate
- This style of shot may be used when trying to shoot the puck from one end of the rink to the other.

Acceleration

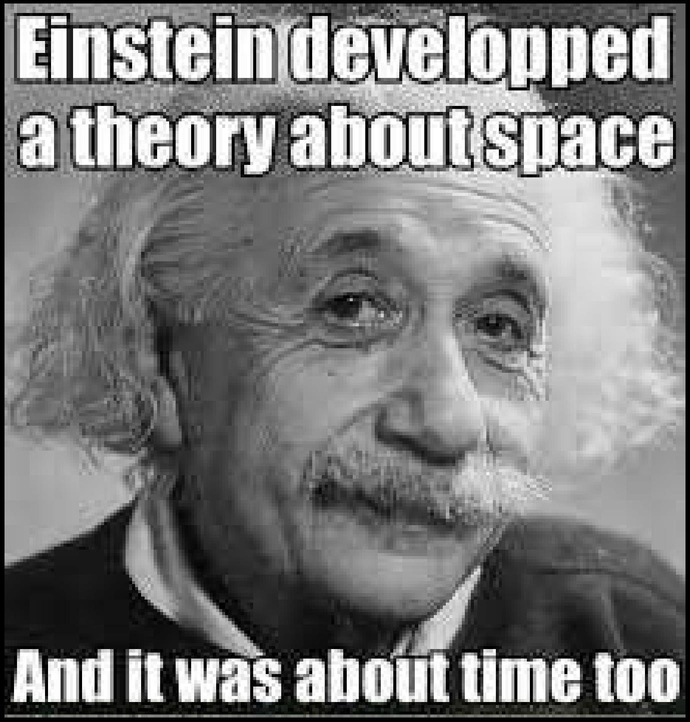
$$Acceleration = \frac{\Delta Velocity}{\Delta time} \ \ in \ \ a \ \ specific \ \ direction$$

- Acceleration in the x-direction equals zero in Physics 1 (No Air Resistance)
- I'll bet you can guess the constant acceleration in the y-direction
- Gravity has an acceleration of $9.8\frac{meters}{second^2}$
- Gravity works on the puck throughout the entire game of hockey.
- If gravity were not accelerating the puck back to the ice surface, the puck would continue to move in a positive x and y direction forever outside of running into the boards or other boundaries.

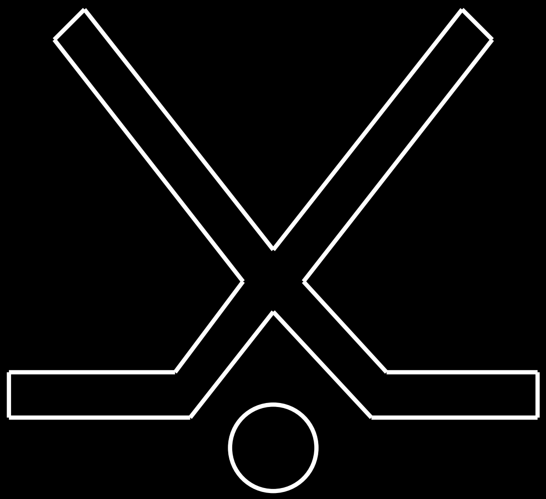
Time

The variable Time is just what we all know it as.

- Time in hockey evaluates the beginning and end of events.
- For projectile motion, its simply the time elapsed while the puck was in the air.
- Time is crucial in finding almost all other variables



Passing and Catching



Factors In Passing

Something so simple in theory like catching a pass may not seem overly complicated, but from a physics standpoint, there are factors that make a difference in how effective you are at catching the puck on your stick.

Two main Factors:

- Impulse- The change in momentum over a period of time
- Torque- Force applied to an object that causes it to rotate

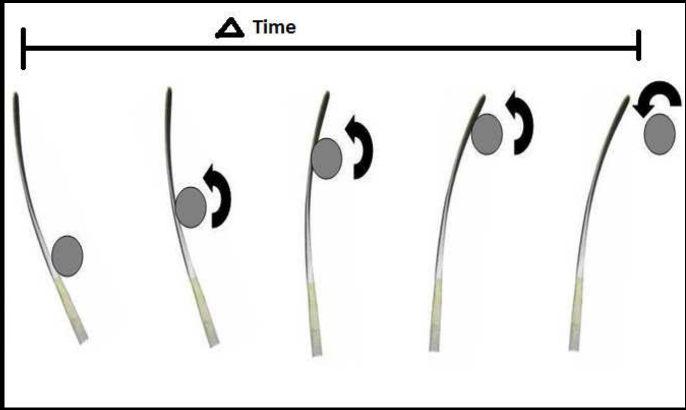


Figure 1: Impulse

Impulse

$$Momentum = Velocity\,of\,pass * Mass\,of\,puck$$

$$Impulse = \frac{\Delta momentum}{\Delta time}$$

In terms of catching a pass, Impulse can be effected 3 ways

1. The velocity of the pass is increased or decreased
2. The mass of the puck is increased or decreased
3. The time elapsed from impact until the puck comes to complete rest is increased or decreased.

Why does Impulse matter?

Applied Impulse

In hockey, if you wanted your teammate to catch the puck more often, it would be beneficial to either:

- Use a lighter puck with less mass
- Or pass the puck to your teammate with less velocity
- On the other side of the pass, accepting the puck over a greater amount of time will allow you to be more successful in catching a pass.

This same idea is applied in many areas of life like:

- The Impulse of an airbag catching your face in a car accident.
- The Impulse of landing on a trampoline versus landing on the hard floor
- The Impulse of receiving a Really hard High-Five

Another tactic in receiving a pass is trying to catch the puck as close to the heel of your blade as possible.
Why would this be?

- The answer involves a concept called Torque.

A general definition of Torque is; A force that causes something to rotate.

Torque relies on 4 variables:

1. Mass of the force
2. Acceleration of the force
3. Radius from heel of the blade
4. Angle between the radius and the force.

Torque

A more technical definition for Torque is:

$$Torque = radius * Force * sin(\theta)$$

The Torque on an object can be effected by increasing or decreasing any of the variables.

How does this apply to catching passes?

- The greater the Torque, the greater the force applied to your stick
- Thus, the harder it is to catch a pass.

For instance, lets compare catching a puck on the toe of your blade to catching a puck closer to the heel of your blade.

Example:

- Lets say two pucks are passed with the same mass and acceleration so when catching them, the force impacting your stick is the same.
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-
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- The 1st pass is caught at a radius 10cm from the heel and the other is caught at the very toe of the blade (radius = 20cm)
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Torque Example

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- Since the value of the radius for the 2nd pass that hit the toe of the stick is 2x greater than pass one, the overall torque applied to the blade by the 2nd pass is going to be 2 times greater and therefore 2 times as hard to catch.

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- Since the overall torque applied to your blade by the second pass was so much higher, there is a better chance that the stick will twist out of your grip and you will miss the pass.
- This happens because the torque from the puck over powered the torque exerted by the grip of your hands on the stick.

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Torque Conclusions

Overall:

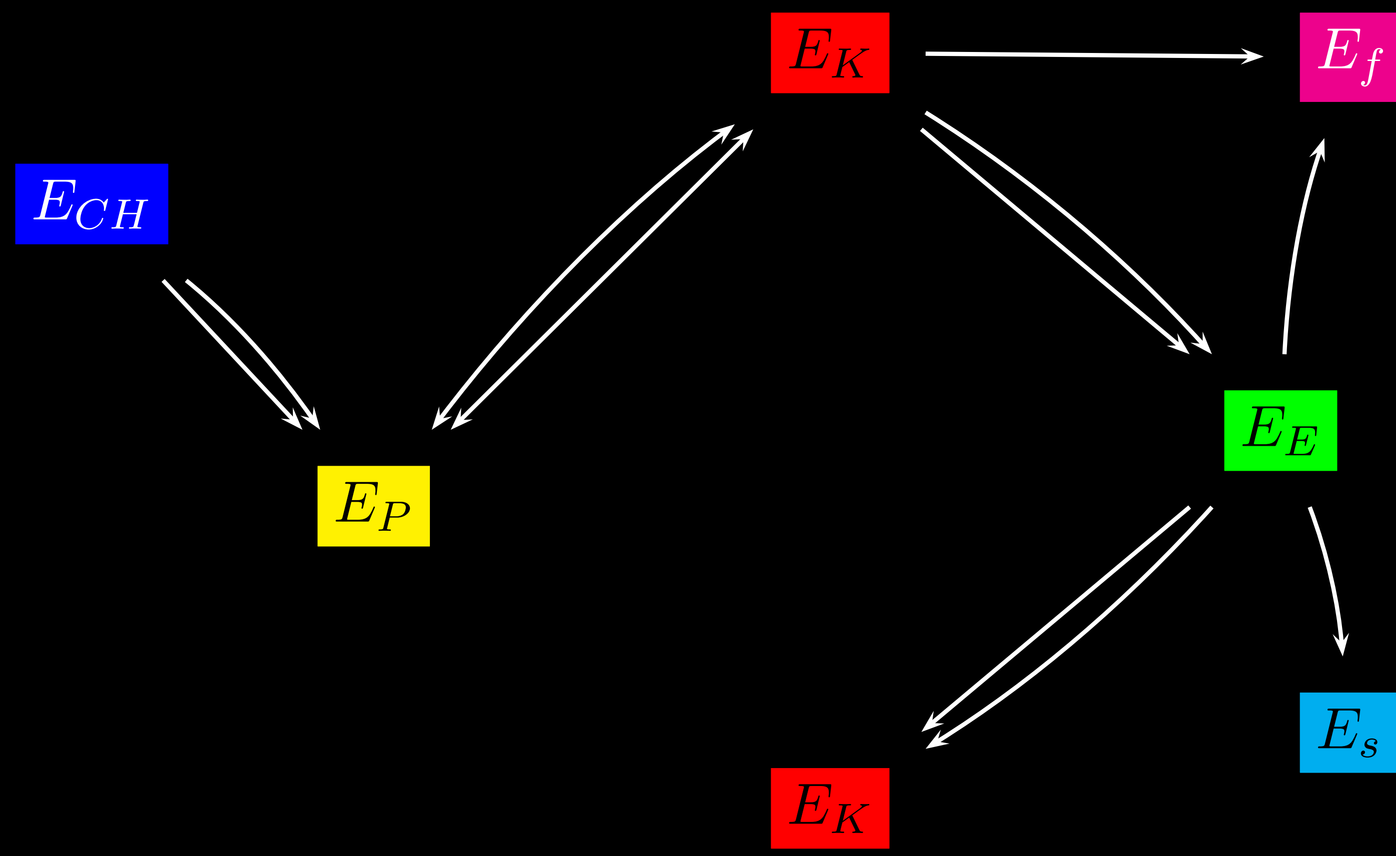
- When the radius is smaller, the overall torque will be smaller.
- Torque explains that is easier to catch a pass closer to the heel of the blade simply because the player's hands will have a smaller torque pushing against them.
- A smaller force and mass also generate a smaller torque which makes the pass easier to catch.

Question: Yes or No?

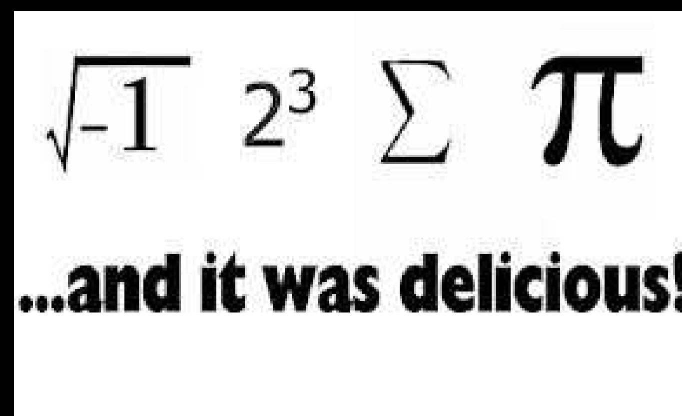
Answer: You turned your head to read this. . .

Energy Transfer in a Slapshot

Transfer of Energy Diamgram



That's Certainly Enough Physics For One Day...



Any Final Questions?