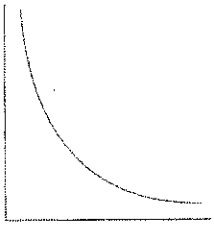
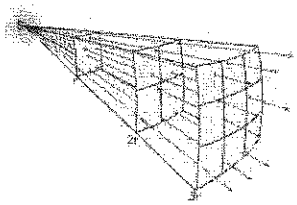
The Universal Gravitation equation reveals a fourth relationship known as **Inverse square**

The graph for inverse square takes the same shape as the inverse graph but perhaps the curve more pronounced



What ever happens to "x" the opposite and square happens to "y"

Equation format is $y = \frac{m}{x^2}$



As the distance from the center increases the strength of the gravitational field is spread out over a larger surface area. If the distance from the center doubles the gravitational field is spread out over 4 times the area, so therefore the gravitational force is 4 times weaker. [ie, as "r" or distance between centers "x" doubles, the F_g or gravitational force of attraction "y" is quartered.]

The equation $F_g = G\frac{m_1 m_2}{r^2}$ reveals a direct relationship between F_g and the product of the masses and an inverse relationship between F_g and the distance between the centers of two masses (r)

TOPIC 3C

Skill 27: Conservation of Momentum

Collisions between objects follow a predictable pattern of behavior due to the fact that momentum is a conserved quantity.

This means that the total momentum of the objects before a collision is equal to the total momentum of the objects after a collision. In equation format this concept can be summarized as

$$p_{before} = p_{after}$$

3 main categories of collisions exist: for any object at rest p=0 since v=0

Elastic collisions - The objects remain separate when the collision occurs. 2 or more objects 2 different velocities.

$$p_{before} = p_{after}$$
$$p_1 + p_2 = p_1' + p_2'$$
$$m_1v_1 + m_2v_2 = m_1v_1' + m_2v_2'$$

Inelastic collisions – The objects stick together when the collision occurs. 2 individual objects combine to a single object with a single velocity.

$$p_{before} = p_{after}$$
$$p_1 + p_2 = (p_1 + p_2)'$$
$$m_1v_1 + m_2v_2 = (m_1 + m_2)v'$$

Separation or Explosions – Two (or more) joined objects separate when the collision event occurs. If one object moves forward the other moves backward. This backward motion, known as **recoil**, is common when firing guns, cannons etc.

$$p_{before} = p_{after}$$
$$0 = p_1 + p_2$$
$$0 = m_1v_1 + m_2v_2$$

REMEMBER VELOCITY AND MOMENTUM ARE BOTH VECTORS. DIRECTION IS INDICATED BY + or – sign.

In order to generate an equation for each scenario you must

- Write an expression for the momentum of each object. Assign each object a number. Use the prime (') symbol to indicate the difference between the before and after velocity if the object is moving both before and after. If two objects are attached and moving with a single velocity add masses in parentheses
- Set the sum of the momentum before equal to the sum of the momentum after.
- Substitute and solve for any unknown values.
- For any object at rest, eliminate term from equation $m_1v_1 + \cancel{m_2v_2} = \cancel{m_1v_1'} + m_2v_2'$

Alternate method - Fill in "mv=p" to solve for unknown

Use equations mv=p for each object and total $p_{before} = p_{after}$		BEFORE		AFTER	
		Object 1	Object 2	Object 1	Object 2
Mass	m				
Velocity	v				
Momentum	p				
Total Momentum					

Example A.

A 5kg bowling ball (object 1) moving at 5 m/s hits a 1kg basketball (object 2) at rest. After the collision the basketball is moving east with a velocity of 3m/s. What is the velocity of the bowling ball?

Step 1: Write expression for each object before and after

Momentum of bowling ball before $p_1 = m_1v_1$ Momentum of bowling ball after $p_1' = m_1v_1'$

Momentum of basketball before $p_2 = m_2v_2$ Momentum of basketball after $p_2 = m_2v_2'$

Step 2: Set the sum of the momentum before to the sum of the momentum after

$p_1 + p_2 = p_1' + p_2'$ or $m_1v_1 + m_2v_2 = m_1v_1' + m_2v_2'$

Step 3: Substitute and solve for any unknown quantities

$m_1v_1 + \cancel{m_2v_2} = m_1v_1' + m_2v_2'$

$(5kg)(5m/s) \cancel{+ 1kg(0)} = (5kg)(v_1') + (1kg)(3m/s)$

$25kg\ m/s = 5kg\ (v_1') + 3kgm/s$

$22kg\ m/s = 5\ kg\ (v_1')$

$v_1' = 4.4m/s$

OR Fill in values on chart.

Use equations mv=p for each object and total $p_{before} = p_{after}$		BEFORE		AFTER	
		Object 1 (bowling)	Object 2 (basket)	Object 1 (bowling)	Object 2 (basket)
Mass	M	5kg	1kg	5 kg	1kg
Velocity	V	5m/s	0	? 4.4m/s	3m/s
Momentum	P	25kg m/s	0	? 22 kg m/s	3 kg m/s
Total Momentum		25kg m/s		25kg m/s	