Gravity. Momentum and Friction

Newton's Universal Law of Gravitation

Vocabulary	Definition	Drawing and/or diagram
Force		
Gravity		
Law of gravitation		
Mass		
Weight		

2. Identify the TWO factors that affect the strength of the force of gravity between two objects.

3. Circle the object that would exert a greater force of gravity on you. **The Earth** or **The Moon**. Explain why the object you chose exerts more gravity on you.

4. Circle the pair of objects with that exert the greatest force of gravity on each other. Explain why.

First pair of objects:

Second pair of objects:

5. Identify the TWO factors that keep a planet in orbit around the sun.

6. Explain how inertia and gravity work together to keep Earth in orbit around the sun.

7. Predict how a planet would move if the sun suddenly disappeared. Hint: Think about Inertia

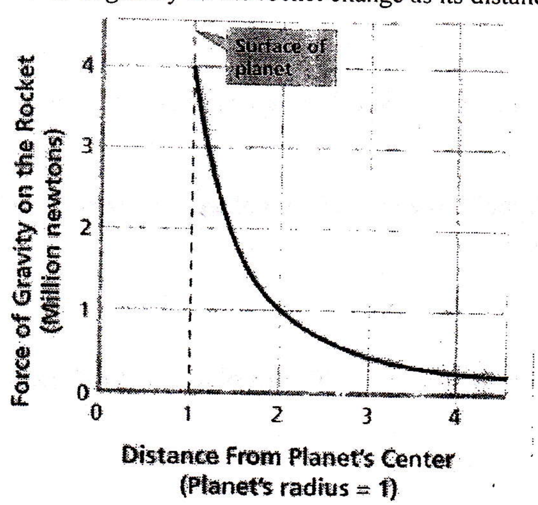
8. Predict how the moon would move if the Earth's mass suddenly doubled. Explain your prediction.

9. As a rocket leaves a planet's surface, the force of gravity between the rocket and the planet changes.

(a) What is the force of gravity on the rocket at the planet's surface?

(b) What is force of gravity at two units (twice the planet's radius from the center?

(c) In general, how does the force of gravity on the rocket change as its distance from the planet increases?



- The equation for the law of universal gravitation is: $\mathbf{F_g = [G*(M_1*M_2)] / d^2}$
- Where **F** is the force of attraction between masses $\mathbf{m_1}$ and $\mathbf{m_2}$ separated by distance **d**, and **G** is 6.67×10^{-11} Nm^2/kg^2.
- The mass of the Earth is $5.97 * 10^{24}$ Kg

1. Two students are sitting 1.50m apart. One student has a mass of 70.0kg and the other has a mass of 52.0kg. What is the gravitational force between them?

2. What gravitational force does the moon produce on the earth if the centers of the moon and earth are $3.88\text{x}10^8$m apart and the moon has a mass of $7.34\text{x}10^{22}$kg?

3. If the gravitational force between two objects of equal mass is $2.30\text{x}10^{-8}$N when the objects are 10.0m apart, what is the mass of each object?

4. Calculate the gravitational force on a $6.50\text{x}10^2$kg spacecraft that is $4.15\text{x}10^6$m above the surface of the earth.

5. The gravitational force between two objects that are $2.1\text{x}10^{-1}$m apart is $3.2\text{x}10^{-6}$N. If the mass of one object is $5.5\text{x}10^1$kg, what is the mass of the other object.

6. If two objects each with a mass of $2.0\text{x}10^2$kg, produce a gravitational force between them of $3.7\text{x}10^{-6}$N, what is the distance between them?

7. What is the gravitational force on a 70.0kg object sitting on the earth's surface?

8. What is the gravitational force on a 35.0kg object standing on the earth's surface?

9. What is the gravitational force on a 70.0kg object that is $6.37\text{x}10^6$m above the surface of the earth?

10. What is the gravitational force on a 70.0kg object that is $3.18\text{x}10^6$m above the earth's surface?

What is Momentum?

A baseball bat and a ball are a pair of objects that collide with each other. Because of Newton's third law of motion, we know that the force the bat has on a baseball is equal to, but opposite in direction to the force of the ball on the bat. The bat and the baseball illustrate that action and reaction forces come in pairs. Similarly, the momentum of the bat before it hits the ball will affect how much momentum the ball has after the bat and ball collide. Likewise, the momentum of the ball coming toward the bat, determines how much force you must use when swinging the bat to get a home run. What is momentum? The momentum (kg*m/sec) of an object is its mass (kg) multiplied by its velocity (m/sec). The equation for momentum where P equals momentum, m equals mass, and v equals velocity, is:

- $P = m * v$ or $P = \text{mass(kg)} * \text{speed (m/sec)}$

The law of conservation of momentum.

The *law of conservation of momentum* states momentum is conserved. This means that the momentum of the bat and ball before the collision is equal to the momentum of the bat and ball after the collision: In other words, for two objects, (1) and (2), the momentum of object (1) is equal to the momentum of object (2). The two colliding objects represent a system. These formulas will help you complete this problem set.

- Momentum of object 1 = momentum of object 2 ($m_1v_1 = m_2v_2$)
- This can also be written as: $m_1v_1 - m_2v_2 = 0$
- The momentum of a system before a collision = the momentum of a system after a collision: $\mathbf{m_1v_1 - m_2v_2 = m_1v_1 - m_2v_2}$

Example Problems:

- A 0.2 kg steel ball that is rolling at a velocity of 3.0 m/sec.
  Momentum = m * v = 0.005 kg * 3m/sec = 0.6 kg*m/sec
- A 0.005 kg bullet with a velocity of 500 m/sec.
  Momentum = m * v = 0.005 kg * 500 m/sec = 2.5 kg*m/sec

Calculate Momentum for the following objects:

1. A 100 kg football player, a fullback, moving at a velocity of 3.5 m/sec.

2. A 75 kg football player, a defensive back, running at a velocity of 5 m/sec.

3. In questions 1 and 2 above, if the fullback collided with the defensive-back, who would get thrown backwards? Explain your answer

4. If a ball is rolling at a velocity of 1.5 m/sec and has a momentum of 10.0 kg*m/sec, what is the mass of the ball?

5. What is the velocity of a 2.5 kg object that has a momentum of 1,000 kg*m/sec?

6. A 2.0 kg object has a momentum of 25 kg*m/sec. What is the object's velocity?

7. A 1.0 kg object has a momentum of 12 kg*m/sec. What is the object's velocity?

8. A 1.5 kg object is thrown at 10 m/sec. What is the ball's momentum?

9. An object is moving at 7.0 m/sec and has a momentum of 100 kg*m/sec. What is the object's mass?

10. An object is moving at 4.5 m/sec and has a momentum of 75 kg*m/sec. What is the object's mass?

11. Your brother's mass is 40 kg and he has a 1.3 kg skateboard. What is the combined momentum of your brother and his skateboard if they are moving at 8.5 m/sec?

Use the law of conservation of momentum formula, $m_1v_1 = m_2v_2$, to answer the following problems. The first one is done as an example

Example: A 0.5 kg ball with a velocity of 2.0 m/sec hits another ball with a mass of 1.0 kg. What is the velocity of the second ball after collision?

If (0.5 kg) * (2.0 m/sec) = (1.0 kg) * (v_2) then ((0.5 kg) * (2.0 m/sec)) / (1.0kg) = V2 = (1.0 m/sec)

12. A 1.0 kg ball with a velocity of 5 m/sec hit another 1.0 kg ball that is stationary. What is the momentum of each ball before the collision?

13. In question (12) above, what is the total momentum before and after the collision?

14. A 20 kg cart with a velocity of 20 m/sec heading *right* collides with a 25 kg cart with a velocity of 10 m/sec heading *left*. What is the momentum of each cart?

15. In question (14) above, what is the total momentum before and after the collision?

16. In question (14) above, if the speed of the 20 kg cart is 10 m/sec after the collision, what is the speed of the 25 kg cart after the collision?

17. In question (14) above, in which direction will each cart travel after the collision?

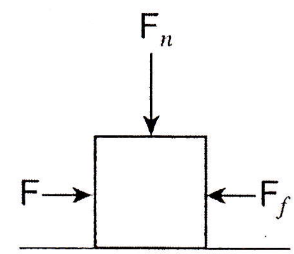
Friction

Friction is a force that resists motion in all real-world mechanics. This skill sheet will provide you with the opportunity to practice solving problems that involve static friction and sliding friction. Static friction is the friction between two surfaces that are not moving. Sliding friction is the friction between two moving surfaces.

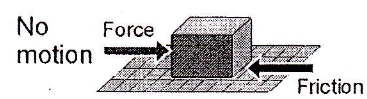
1. Calculating friction

In the illustration below, a force (F) is applied to an object. This force is resisted by friction (F_f), also a force.

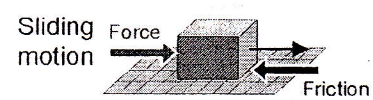
Note that the normal force, (F_n), includes all forces pressing the moving surfaces together.



STATIC FRICTION



SLIDING FRICTION



Here is the equation for finding friction:

Friction

Coefficient of friction

Friction force (N) $F_f = \mu F_n$ ← Normal force (N)

In this equation:

- F_f = force of friction.
- μ = coefficient of friction.
- F_n = normal force (force pressing together).

Example: A cinder block sitting on a sidewalk weighs 90 newtons. The coefficient of friction is 0.4. How much force is required to start the block sliding?

$$F_f = \mu \times F_n$$
$$F_f = 0.4 \times 90 \text{ N}$$
$$F_f = 36 \text{ N}$$

To slide the block, F must be greater than 36 N.

2. Static friction

Solve these problems and state your answers in the following way: "More than _____ newtons of force is needed." Fill in the blank with the correct number of newtons.

1. A huge pile of leaves was wrapped in a tarp in the middle of a lawn. The wrapped leaves weigh 580 newtons. The coefficient of friction for the lawn is 0.55. How much force is required to start sliding the wrapped leaves?

2. Although the collie Lassie could easily pull the 110-newton sled empty, she could not even budge it with 380-newton Timmy aboard. How much force would Lassie have to apply to slide the sled with Timmy aboard? Assume a coefficient of friction of 0.15.

3. The plastic wading pool weighs 50 newtons. But the water in it weighs 4,000 newtons. How much force is required to slide the filled pool if the coefficient of friction is 0.22?

4. The boys pushed and pushed. At an applied force of 804 newtons, they were just able to move the 1,340-newton car. What was the coefficient of friction?

5. At an applied force of 530 newtons, the boulder just began to slide. Assuming a coefficient of friction of 0.65, how much did the boulder weigh?

3. Sliding friction

Sliding friction is usually less than static friction. Each of the problems below is related to those in part 2.

1. Although the pile of leaves in the tarp still weighed 580 newtons, once the family that had raked and wrapped them up got the huge bundle moving, it was easy to keep it moving. The family estimated that they were applying 93 newtons of force. What was the coefficient of sliding friction?

2. Aboard the sled, Timmy kicked off with his feet, and although it wasn't easy, Lassie was able to pull the combined 490-newton weight of sled and Timmy. Assuming that the sliding coefficient of friction was 0.05, how much force was Lassie applying to the sled?

3. The children had been splashing in the pool all day. Their father was surprised that he could drag the plastic wading pool over the wet grass if he gave it a jerk to get it started. Assume the coefficient of sliding friction is now 0.08. How much force must he apply to the 4,050-newton pool (and water) once it is moving?

4. The boys were relieved to find that the 1,340-newton car was easier to push once it got going. Just how hard did they have to push, assuming a coefficient of friction of 0.4?

5. Try to do this one logically in your head. The boulder in problem 5 in Part 2 required 530 newtons of force to just begin to slide at a coefficient of static friction of 0.65. What is the coefficient of sliding friction if the force required to keep it moving is 265 newtons, half of the 530 newtons? Check your work using the boulder's weight you calculated in the earlier problem.