

Forces and Motion

Chapter 12 – Prentice Hall
Physical Science

1

Forces

- **Force:** a push or pull that acts on an object
- Forces cause changes in motion.
- SI Unit: Newton (N) (the force required to accelerate a 1-kg object by 1 m/s²)

$$1 \text{ N} = 1 \text{ kg} \cdot \text{m/s}^2$$

- Forces are vectors – they are described by both a number and a direction.

2

Isaac Newton

- Isaac Newton (1643-1727) was a British scientist and theologian who introduced the 3 laws of motion that we still use today.
- In addition to his advances in physics, Newton accomplished the following:
 - Invented calculus (a credit shared with Leibnitz, another mathematician)
 - Contributed to optics and astronomy
 - Studied alchemy
 - Delved into theology



Godfrey Kneller's 1689 portrait of Isaac Newton (aged 46) (Source: "Isaac Newton" - Wikipedia)

3

Newton's 1st Law of Motion

- *The state of motion of an object will NOT change as long as the NET FORCE acting on it is ZERO.*
- Newton's 1st Law is also known as the "Law of Inertia"
- **Inertia:** tendency of an object to resist changes in its state of motion
- *What does a ZERO NET FORCE mean?*
 - *The forces on the object are BALANCED.*

4

Newton's 2nd Law of Motion

- *The acceleration of an object is equal to the net force acting on it divided by its mass, or:*

$$\text{Acceleration} = \frac{\text{Net Force}}{\text{Mass}}$$

$$a = \frac{F}{m}$$

- The direction of acceleration will be the same as the direction of the net force.

5

Calculating with Newton's 2nd Law (Math Skills p. 367)

- A car with a mass of 1000 kg accelerates when the light turns green. If the net force on the car is 4000 N, what is the acceleration?

$$m = 1000 \text{ kg}$$

$$F = 4000 \text{ N}$$

$$a = ?$$

$$a = \frac{F}{m} = \frac{4000 \text{ N}}{1000 \text{ kg}} = \frac{4000 \text{ kg} \cdot \text{m/s}^2}{1000 \text{ kg}} = 4 \text{ m/s}^2$$

- Now do Math Practice #3 on white boards/paper...

6

Weight and Newton's 2nd Law

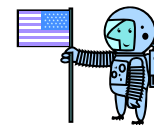
- Weight and Mass are two DIFFERENT things:
 - Mass is a measure of *INERTIA*
 - Weight is a measure of the *FORCE OF GRAVITY* acting on an object
- If we know the acceleration due to gravity and an object's mass, we can calculate weight using Newton's 2nd Law:

$$\text{Weight} = \text{Mass} \times \text{Acceleration}$$

7

Weight and Newton's 2nd Law

- Imagine identical twin astronauts. Which weighs more, the astronaut on Earth or the astronaut on the Moon?



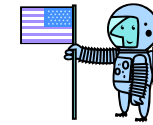
Astronaut on Earth

$$a = 9.8 \text{ m/s}^2$$

$$W = ma$$

$$W = (150 \text{ kg})(9.8 \text{ m/s}^2)$$

$$W = 1470 \text{ N}$$



Astronaut on Moon

$$a = 1.6 \text{ m/s}^2$$

$$W = ma$$

$$W = (150 \text{ kg})(1.6 \text{ m/s}^2)$$

$$W = 240 \text{ N}$$

8

Newton's 3rd Law

- *When one object exerts a force on a second object, the second object exerts an equal and opposite force on the first.*
 - The two forces are called Action/Reaction forces.
 - Equal refers to size. Opposite refers to direction.
- Why don't the action and reaction forces cancel?
 - They act on different objects.
- Think [billiards](#) and [bumper cars!](#)

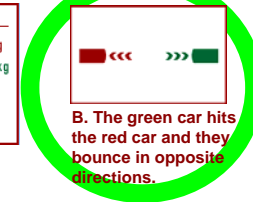
9

Check your understanding...

- Two bumper cars are in a head-on collision. Each car has a mass of 300 kilograms, and is moving with the same speed in opposite directions.
- What will happen? Select the outcome of the collision from the two choices below.



A. The cars bump and stop moving in the same direction.



B. The green car hits the red car and they bounce in opposite directions.

Source: <http://www.learner.org/interactives/parkphysics/bumpercars/collision1.html>

10

Universal Forces

- Electromagnetic Force
 - Associated with charged particles (ions, protons, electrons)
 - Only force that can both attract and repel
- Strong and Weak Nuclear Forces (only act on protons and neutrons in nucleus)
- **Gravitational Force**
 - Weakest universal force
 - Newton's Law of Universal Gravitation describes the gravitational force

11

Newton's Law of Universal Gravitation

- Every object in the universe attracts every other object.
- Force of gravity depends on the masses of the two objects involved and the distance between the objects:

$$F_g = G \frac{m_1 m_2}{r^2}$$

m_1 = mass of object 1

m_2 = mass of object 2

r = distance between two objects

G = Universal Gravitational Constant

12

Let's watch gravity in motion...

- [Solar System Simulator](#)

- To run this at home, go to http://phet.colorado.edu/simulations/sims.php?sim=My_Solar_System and click on the green "Run Now!" button
- Look at the "Select Preset" option – start with sun, moon and planet. Hit start and see what happens!
- You can hit stop and mouse over the various bodies to see their instantaneous velocities and positions. You can also change the masses and distances between objects – play around with it.

13

Check your Understanding...

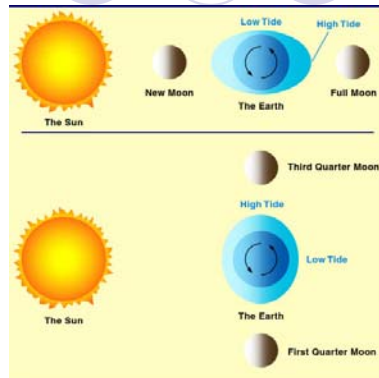
- Gravity acts over LONG distances.
- What happens to the force of gravity as the mass of one or both objects increases?
 - The force goes up.
- What happens to the force of gravity as the distance between the objects increases?
 - The force decreases.

14

Gravity and Tides

- Tides

- Tides are caused by the force of gravity of the moon on the Earth and its oceans
- The sun has some effect, too, but it is MUCH farther away, so its effect on tides is about half that of the moon.



http://www.lcsd.gov.hk/CE/Museum/Space/EducationResource/Universe/framed_e/lecture/ch06/ch06_cnt.html

15

Satellites

- We use artificial satellites for weather monitoring, communications, investigating Earth's surface, studying space (Hubble space telescope), and surveillance/defense
- To stay in orbit, satellites use 2 things:
 - Momentum given them when they are launched at a certain speed, and
 - Earth's gravitational field (acts as a *centripetal force* – a force directed toward the center of an objects circular path)
- View a satellite orbit diagram and learn more at: http://en.wikipedia.org/wiki/File:Orbits_around_earth_scale_diagram.svg

16