L-3 Gravity and Free Fall

- Review Principle of inertia (Galileo)
- Inertia: the tendency of objects to resist <u>changes</u> in motion.
 - If an object is at rest, is stays at rest.
 - If an object is moving with constant velocity, it continues moving with constant velocity unless something stops it.
- The inertia of an object is measured by its mass in kilograms (kg) – the quantity of matter in it.

Forces can change velocity

- No force is required to keep an object moving with constant velocity.
- acceleration is a change in velocity
- A net force must be applied to an object to produce an acceleration
- · For example:
 - If an object is at rest, you must push it to get it to move
 - If it is moving, a force must be applied to stop it, e.g., friction, air resistance

The force of gravity

- We will first consider a common force that can accelerate an object: gravity
- As an object falls its velocity constantly increases; the velocity of an object thrown upward constantly decreases as it rises
- The force of gravity depends on the mass of the object
- Gravity keeps us on Earth, the Moon in its orbit, and the Earth in orbit around the Sun; gravity holds the Universe together.







A little astronomy

- The planets revolve around the sun in approximately circular paths (Kepler)
- The further the planet is from the sun the longer it takes to go around (Kepler)
 - the time for a planet to go completely around the sun is a <u>year</u>
 - the earth spins on its axis once every day
 - the moon revolves around the earth about once every <u>month</u>

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What does your weight depend on?

- The weight w of an object depends on its mass and the local strength of gravity- we call this *g*
- **g** is the acceleration due to gravity
- Wherever you are on the earth, it pulls you with a force that points to the <u>center</u> of the earth



What is this thing called g?

- g is something you often hear about, for example you might hear that a fighter pilot experiences 2 g's when turning his jet.
- g is the acceleration due to gravity
- When an object falls its speed *increases* as it descends; the speed of a rising object *decreases* as it ascends
- g is the amount by which the speed of a falling object increases each second – about 10 meters per second each second or 10 m/s²
- A more precise value for g is 9.80665 m/s², but we will use g ≈ 10 m/s² in this course





How to calculate weight

- Weight (w)
 - = mass (m) x acceleration due to gravity (g)
- w = m × g = mg
- Units to be used in this formula:
 - m is in kilograms (kg)
 - g \approx 10 m/s²
 - w is in force units called Newtons (N)
 - \approx means approximately equal to

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example

Question: What is the weight of a 100 kg object?

<u>Answer:</u> $w = m x g = 100 \text{ kg } x 10 \text{ m/s}^2 = 1000 \text{ N}$

- One Newton is equal to 0.225 pounds (lb), so in these common units 1000 N = 225 lb
- Often weights are given by the equivalent mass in kilograms. We would say that a 225 lb man "weighs" 100 kg; this is commonly done but, it is technically incorrect.

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Compared to Earth, you weigh more on Jupiter and less on the Moon

- Your mass is the same everywhere, but your weight depends on where you are, since g depends on the mass of the planet.
- On the moon g_{moon} ≈ 1.6 m/s² ≈ (1/6) g on earth, so your weight on the moon is only (1/6) your weight on earth. (The moon's gravity is too weak to have an atmosphere.)
- On Jupiter, g ≈ 23 m/s² ≈ 2.3 g on earth, so on Jupiter you weigh 2.3 times what you weigh on earth









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