Review – inertia

- Tendency of objects to resist changes in motion.
- The inertia of an object is measured by its mass – the quantity of matter in it.
- If an object is at rest stays at rest.
- If an object is moving with constant velocity, it continues moving until something stops it.

Forces can change velocity!

- No force is required to keep an object moving with constant velocity.
- What can change the velocity of an object? FORCES
  - acceleration is a change in velocity
  - forces produce accelerations
  - for example- friction or air resistance

The force of gravity

- Today we will explore one force that can change the velocity of an object
  - GRAVITY
- Everything that has mass is affected by gravity
- It is the most common force we have to deal with – it’s what keeps us on earth and the earth revolving around the SUN.

Weight and gravity

- All objects exert an attractive force on each other – Universal Law of Gravity
  - Your weight is the attractive force that the earth exerts on you- it’s what makes things fall!
- All objects are pulled toward the center of the earth by gravity.
- The sun’s gravity is what holds the solar system together.

The sun is the most massive object in the solar system, about 3 million times the earth’s mass and 1000 times more massive than the most massive planet-Jupiter

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 to go around the sun is a year
  * the earth spins on its axis once every day
  * the moon revolves around the earth once every month

Astronomers have recently decided that PLUTO is too small to be considered a planet. IN THIS COURSE PLUTO IS A PLANET!
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 \( g \) – the acceleration due to gravity.
- Weight points toward the earth's center.
- Sometimes down is up!

What is this thing called \( g \)?

- \( g \) is something you often hear about, for example.
- You might hear that a fighter pilot experienced so many \( g \)'s when turning his jet plane.
- \( g \) is the acceleration due to gravity.
- When an object falls its speed increases as it descends.
- acceleration is the rate of change of velocity.
- \( g \) is the amount by which the speed of a falling object increases each second – about 10 m/s each second (9.8 m/s/s to be exact).

Example – a falling object

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<th>velocity (m/s)</th>
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<td>5</td>
<td>50</td>
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</table>

How to calculate weight

- Weight = mass x acceleration due to gravity.
- \( W = m \times g \) (mass times \( g \)).
- In this formula \( m \) is given in kilograms (kg) and \( g \approx 10 \text{ meters per second per second} \) (m/s²), then \( w \) comes out in force units – Newtons (N).

You weigh more on Jupiter and less on the moon

- The value of \( g \) depends on where you are, since it depends on the mass of the planet.
- On the moon \( g \approx 1.6 \text{ m/s}^2 \approx (1/6) g \) on earth, so your weight on the moon is only \( (1/6) \) your weight on earth.
- On Jupiter \( g \approx 23 \text{ m/s}^2 \approx 2.3 g \) on earth, so on Jupiter you weigh 2.3 times what you weigh on earth.

Example

- What is the weight of a 100 kg object?
- \( W = m \times g = 100 \text{ kg} \times 10 \text{ m/s}^2 = 1000 \text{ N} \)

- One Newton is equal to 0.225 lb, so in these common units \( 1000 \text{ N} = 225 \text{ lb} \).
- Often weights are given by the equivalent mass in kilograms, we would say that a 225 lb man "weighs" 100 kg.
Get on the scale:
How to weigh yourself

- spring force
- m
- weight

Free Fall
- Galileo showed that all objects (regardless of mass) fall to earth with the same acceleration $g = 10 \text{ m/s}^2$
- This is only true if we remove the effects of air resistance. demos
- We can show this by dropping two very different objects inside a chamber that has the air removed.

Galileo's experiments
- To test this we must drop two objects from the same height and measure the time they take to fall.
- If H isn't too big, then the effects of air resistance are minimized

On the other hand . . .
- If you drop an object from a small height it falls so quickly that it is difficult to make an accurate measurement of the time
- We can show experimentally that it takes less than half a second for a mass to fall 1 meter. (demo)
- How did Galileo deal with this?

Galileo made g smaller!
- Can be made small by using a small h or big D

What did Galileo learn from the inclined plane experiments?
- He measured the time it took for different masses to fall down the inclined plane.
- He found that different masses take the same time to fall down the inclined plane.
- Since they all fall the same distance, he concluded that their accelerations must also be the same.
- By using different distances he was able to discover the relation between time and distance.
- How did Galileo deal with friction?
How did Galileo measure the time?

- Galileo either used his own pulse as a clock (he was trained to be a physician).
- Or, a pendulum.

Problem - Around the world

- How long would it take for the B2 bomber to fly around the world?
- The B2 can fly at Mach 0.85 (subsonic) which means 0.85 times the speed of sound 730 mph (330 m/s).
- speed = 0.85 \times 730 \text{ mph} = 618 \text{ mph}
- Earth's circumference = 25,000 \text{ mi}
- time = \frac{\text{distance}}{\text{speed}} = \frac{25,000 \text{ mi}}{618 \text{ mph}} = 40 \text{ hr}