2398131: Physics in Films
Oct 9, 2017

Topics to discuss

- Few points you may learn from "Spider-Man 2" (2004)
  - Energy and work (in physics)

Falling object

If you drop something, it will fall. **The gravitational acceleration at the surface of the Earth is g = 10 m/s²** (To be precise, which we don't here, g varies from 9.7X to 9.8Y m/s² depending on latitude). What does **it** mean?

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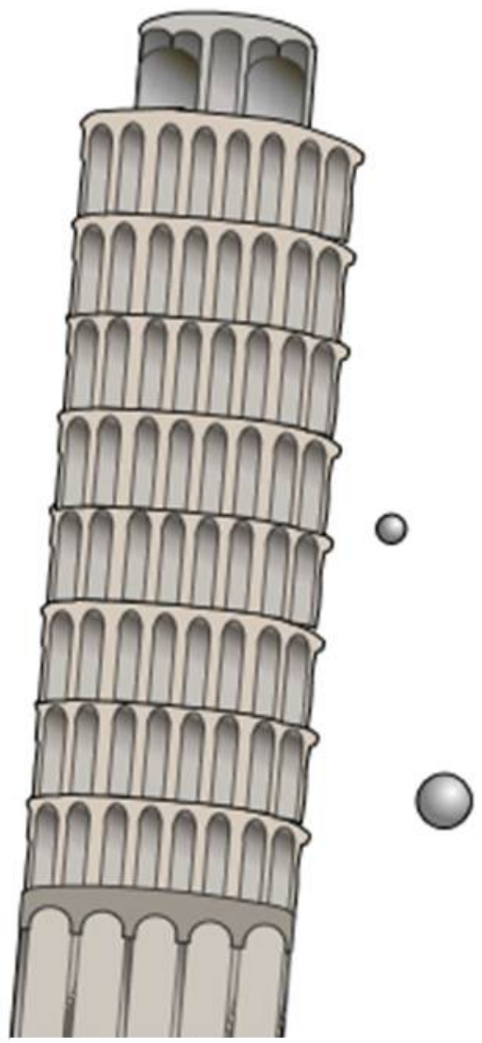
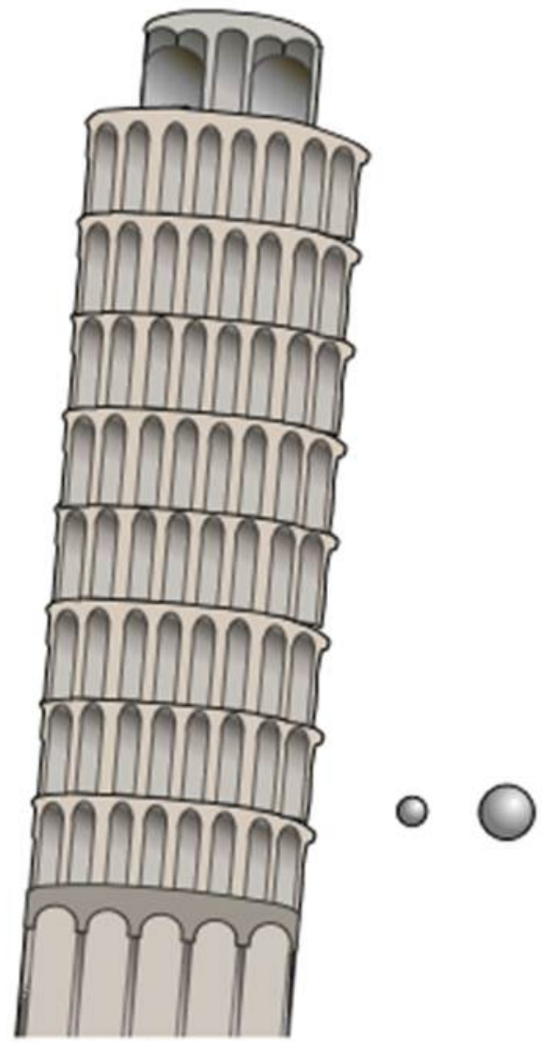
- This means that a falling object will increase its speed by 10 m/s every second. If you fell for 5s, you would hit the ground at 50 m/s!

- The gravitational acceleration (and also the final speed) does **not** depend on mass!
  - Air resistance

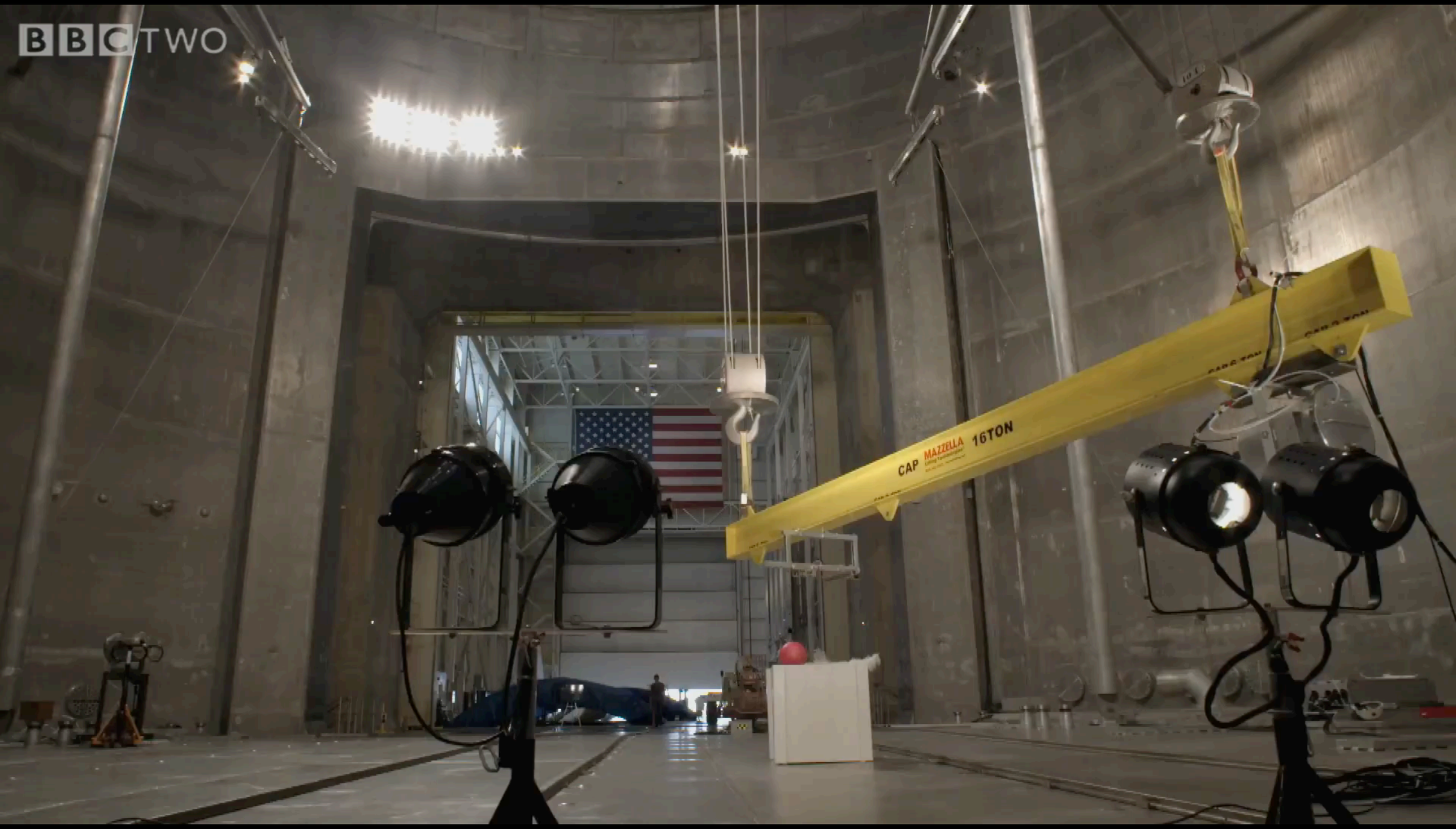


Aristotle



Galileo

Falling object



Gravitational force

There is the gravitational force which is in general can be expressed as $F = mg$, where m is the mass in kilograms. Thus, a 1-kg block experiences a gravitational force of 10 Newton on Earth (less on the moon and more on the "surface" of Jupiter).

- The weight of an object of a given mass is the force of gravity on that object.
- This difference between mass and weight can be confusing.

The object has the same mass everywhere, but the weight depends on the planetary gravity.

Potential Energy

It takes work to lift an object against the force of Earth's gravity. The energy needed to do this is called the potential energy

$$\text{Potential Energy} = m\,g\,h$$

where *h* is the height in meters. This makes sense. If you increase the mass of the lifted object, or the height you lift it to, or the gravitational pull, then you will need more energy to lift the object. The metric unit of energy is the joule, abbreviated J.

Question

How much do you change your potential energy climbing the Doi Inthanon from the sea level?
How does this compare to the energy from a bottle of Coca-Cola?

- Doi Inthanon height: 2565 m from the sea level.
- Energy from a bottle of Coca-Cola (450 ml): 334,720 J (80 kCal)

Kinetic Energy

It takes work to make an object change its speed (e.g., from 0 to 120 km/h) even ignoring pesky details such as friction and air resistance. The kinetic energy (energy of motion) of an object (in joules) is

$$\text{Kinetic Energy} = 1/2\ m\ v^2$$

where m is the mass in kilograms and v is the velocity (or speed) in meters per second.

If you drop a water balloon from a building, it will start with a large amount of potential energy (PE), convert PE to KE as it falls, and then convert KE to a large splash as it hits.

Question

What is the kinetic energy (in joules) of a car at highway speed (120 km/h) ? How does this compare to the energy from a bottle of Coca-Cola?

Work

"**Work**" is not just a generic term. In physics it **means transferring energy by pushing on something (applying a force) and making it move**. When you kick a football, you are applying a force over a distance. When you shoot a bullet from a gun, the expanding gases in the gun barrel exert a force over a distance. When you apply the brakes in your car, the ground applies a force on your car over a distance. The energy transferred by this force is

$$\textbf{Work} = F\,d$$

where F is the force (in newtons) and d is the distance over which the force is applied (in meters). **Note that the force must be in the same (or opposite) direction as the distance traveled.** If you push in the same direction that the object travels, you increase its energy and speed (e.g., kicking a football). If you push in the opposite direction, then you decrease the object's energy and speed (e.g., apply the brakes). Thus, **Work = Change in kinetic energy**.

It's important to note that if you push sideways (perpendicular to the object's motion), then you do no work (in physics-sense).

Spider-Man 2 (2004)

Peter Parker is beset with troubles in his failing personal life as he battles a brilliant scientist named Doctor Otto Octavius.

We will now watch the scene that Spider-Man stops a runaway New York City six-car subway train by attaching his webs to nearby buildings and pulling really hard (~10 min).

Work

Question

How much force does Spider-Man have to exert to stop the subway train? Give your answer in newtons. Do you think it's possible for Spider-Man, why?

- 6 cars in the train, each car weights 20,000 kg.
- Speed is 20 m/s.
- Distance to stop = 1 kilometer.