Newton’s First Law…

- What makes a person or object accelerate?
- It is perhaps contrary to usual experience, but the normal state of motion is to keep doing what you have been doing
  - Moving objects tend to keep moving
  - Stationary objects tend to stay stationary
- This is Newton’s First Law - the “Law of Inertia”
  “Every body continues in a state of rest or motion in a straight line unless it is compelled to change its motion by external forces exerted upon it.”

…doesn’t work????

- What we really observe in everyday life is that moving objects tend to slow down and eventually stop. Why?
- Why does a car stop if you take the foot off the accelerator?
- How do I keep a moving object moving?
- Forces!
- Newton’s first law does work, but there are usually frictional forces opposing the motion.

What is Force?

- What is a force?
  - Naively, perhaps a push or a pull
- What we really see is the effect of a force - e.g. deforming a tennis ball when hit by a racquet
- “Force is an agent of change”
- “Force is that which alters motion”
- Force defies a really satisfactory definition
  “If you insist on a precise definition of force, you will never get it” — Richard Feynman (Nobel Laureate)

Force has direction

- The unit of force is the Newton (N) = kg.m/s²
- Several forces acting at one point on an object act add up and as a single force
- There are 5 horizontal forces in the tug-of-war - the man on the left experiences one large force although there are 4 individual forces

Forces at angles

- To determine the net force exerted on the stationary elephant by the two clowns you need to allow for the angles involved.

Newton’s Second Law

- The first law tells us that the motion of an object changes with the application of a net force - but by how much?
- This is expressed in Newton’s Second Law which we will write as
  “The acceleration of an object is directly proportional to the net force acting on it. It is in the direction of the net force and inversely proportional to the mass of the object.”
  \[ a = \frac{F}{m} \quad \text{or} \quad F = ma \]
Examples

• The blocks accelerate in the direction of F for as long as the force is applied.
• They will then continue to move at their final speed so long as no other forces (e.g. friction) are acting.

F = ma

Things to note:
• F is the net force (the sum of all the forces) acting on the object.
• If there is a net force then there is an acceleration.
• If there is an acceleration then there is a net force.
• Force and acceleration are in the same direction.

Gravity as a Force

• Perhaps the most obvious force is gravity - which produces the acceleration due to gravity (g = 9.8 m/s$^2$).
• The gravitational force is directed downward - toward the centre of the Earth.
• The force of gravity between any two objects is proportional to their masses and inversely proportional to the square of the distance between them.

Weight - Gravitational Force

• Weight is the downward gravitational force experienced by an object. The weight force is related to the acceleration due to gravity (g = 9.8 m/s$^2$) - a constant:

$$ F_{\text{gravity}} = G \frac{M_{\text{earth}} m}{r^2} = mg $$

• We might say a person’s “weight” is 50 kg. We should say her mass is 50 kg and her weight is $50 \text{ kg} \times 9.8 \text{ m/s}^2 = 490 \text{ N}$.

Summary

• **Newton’s First Law** - objects continue in a state of rest or motion in a straight line unless acted on by external forces.
• **Newton’s Second Law** - often summarised as $F = ma$.
• Weight is the downward gravitational force experienced by an object.

• NEXT: Floating