Tues: Regular class

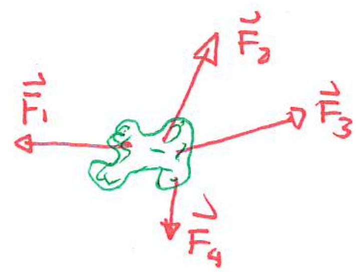
Weds: Review, Exam I

Fri: Exam I → covers classes 1→11 all kinematics
HW 1→4

Newton's First Law

If multiple forces act on an object then we form:

> The net force on the object is
>
> $$\vec{F}_{net} = \sum \vec{F}_i = \vec{F}_1 + \vec{F}_2 + \dots$$



Then the first situation to consider is when the net force is zero. Here Newton's first Law states:

> The net force on an object is zero ⇔ acceleration of the object is zero
>
> object moves in a straight line with constant speed.

Quiz 1 60% → 70% } 90%

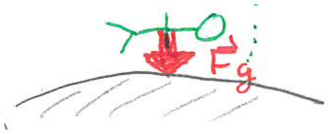
Quiz 2 90% } 90%

DEMO: Hoop / ball

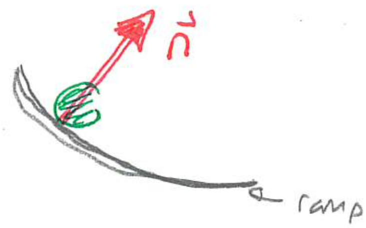
Examples of forces

For terrestrial physics and ordinary situations, the following forces are common:

1) gravity – force exerted by all the mass in the bulk of Earth
   - points straight down to center of Earth.
   - also called gravitational force or weight



2) normal force ~ force exerted by one surface on another
   - contact force
   - perpendicular to surface



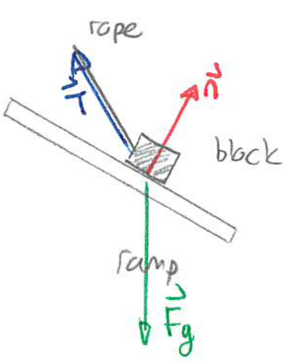
3) tension – force exerted by a rope, cable, wire
   - along direction of rope pull.

Free body diagrams

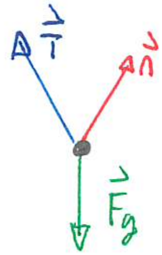
We need to account for all the forces that act on a body and this is done using a free-body diagram:

* a dot represents the object
* one vector for each force – tail of vector on dot.

For example consider a block lowered down a frictionless ramp.

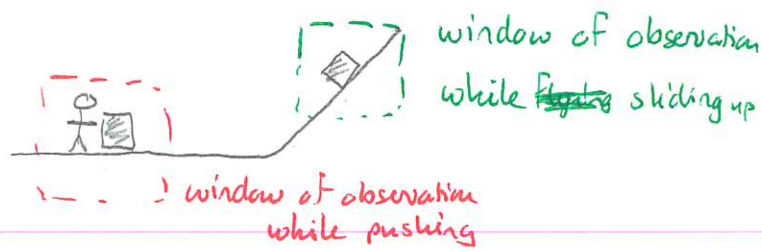


FBD ⇝



Quiz3 70% ~70% { 60% – 80%

Quiz4 40% → 50% { 30% – 60%



Dynamical effects of forces

When the net force on an object is non-zero then Newton's First Law implies that its acceleration is non-zero. Can we predict the acceleration? This requires:

1) a method for quantifying forces and describing magnitudes of forces
2) a method for relating non-zero net force and acceleration.

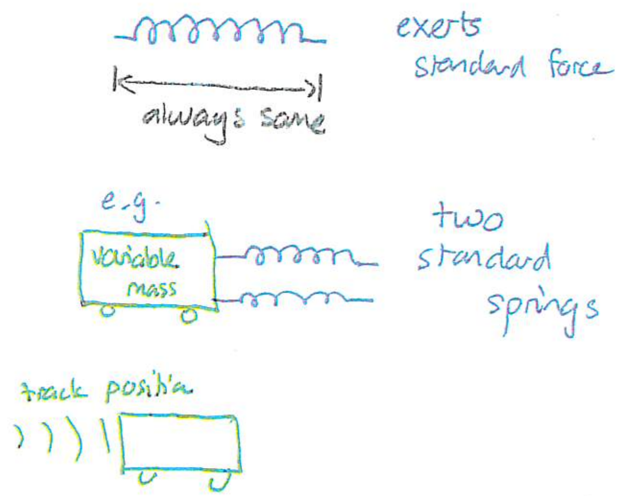
The scheme is:

Select a special object that produces standard forces and can be duplicated.

↳ Apply various numbers of these to objects with variable masses

↳ Observe motion of objects.

standard spring stretched to standard length



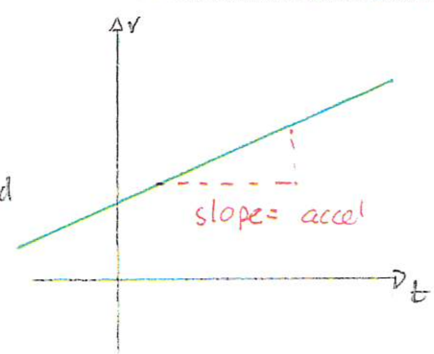
Demo: Cart / springs

Observations indicate

In the absence of all other interactions

1) graph of v vs t ≡ straight line.
2) the acceleration in any single situation is constant and
   a) is inversely proportional to mass of object
   b) directly proportional to force on object

$$\Rightarrow \quad a = \text{const} \times F/m$$



Warm Up 1

The proportionality constant is fixed by setting the force units.

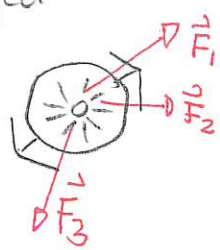
A force of one Newton (N) in the absence of any other forces causes an object with mass 1.0kg to accelerate with acceleration 1.0m/s²

It then becomes exactly true that $F = ma$.

Newton's Second Law.

When multiple forces act on an object the acceleration is predicted via Newton's Second Law:

1) Consider an object of interest. Let m be the mass of the object



2) List (FBD) all forces acting on the object of interest. Then the net force is

$$\vec{F}_{net} = \sum \vec{F}_1 + \vec{F}_2 + \ldots = \sum \vec{F}_i$$

ADD VECTORS

3) the acceleration of the object is given by

$$\vec{F}_{net} = m\vec{a}$$

Warm up 2

Note:

Forces are related to changes in velocity (acceleration)

Forces are not immediately connected to velocity.

~~Warm up~~ ~~Warm up 2~~

We can explore this further:

1) Is the direction of the net force the same as the direction of motion?

Quiz #5 70% → 100% } 80% – 100%

Sometimes the net force is along the direction of motion
Sometimes the net force is NOT along the direction of motion

2) Is the size of the net force correlated to velocity?

Quiz 6 80% – } 60% – 70%

In different situations the net force on an object can be the same while the velocity can be different

DEMO: PhET Forces and Motion

* Force Graphs Tab
* Settings → no friction
  → ~~file cabinet~~ sleepy dog
* Display force / velocity.
* Set F=100 for a while, pause, then F=0

Note: Force constant ≠ 0 ⇒ ~~speed~~ velocity changes
Force = 0 ⇒ velocity constant.