LECTURE #13 – SUMMARY

Section III.3 Forces - Gravity, Tension, Normal Forces

Examples of classical forces:
"contact" forces - act across contact zones (e.g., friction, normal)
"distance" forces - act at a distance (e.g., gravity, magnetism)

The modern view is that all forces arise from a single, as yet unknown, fundamental force → "unification theories" (topic for Spring term)
The practical view involves classifying forces in a way that simplifies the application of Newton's Laws.

(A) The Gravity Force ($\vec{F}_g$)

direction - downward
magnitude = mg Newtons (g = 9.8 m/s^2)

$\vec{F}_g = m\vec{g}$ where $\vec{g} = g\hat{j}$ and $\hat{j}$ is now positive downwards

What is another word for $\vec{F}_g$? $\vec{W} = \text{weight} = \vec{F}_g = m\vec{g}$

Weight depends on g. It is different on the Moon and on the Earth.

Remember that weight ≠ mass !
Mass is an inherent property of an object. It is the same everywhere.

- In the SI system, mass (kg) and weight (N) are often confused.
- In the English system, weight (lb) is more commonly used than mass (slugs).

Two interesting observations.
(1) g is independent of m, so

- acceleration due to gravity is the same for all masses
- $F_g = W \propto m$ (universal law of gravitation)

(2) Weightlessness and apparent weightlessness
When is an object weightless? When m = 0 or g = 0 (outer space).

Are astronauts in the Space Shuttle weightless? No!
This is because they have mass and g = 9.3 m/s^2 (93% of surface value).

So why does it look and feel like they are weightless?!

- because g is independent of mass, all objects accelerate at the same rate (i.e., both the astronauts and the Space Shuttle)
- the astronauts only feel gravity if it is opposed by another force
- this is called <u>apparent weightlessness</u> (or <u>microgravity</u>)

(B) Tension ($\vec{T}$)

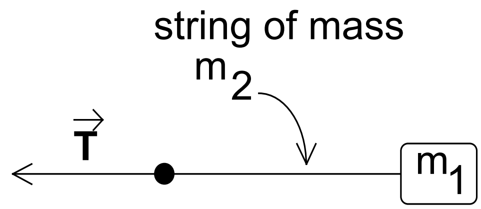
Tension can only pull on an object (not push it) and it is associated with molecular interactions in the string, rope, etc.

direction - in the direction of the string, rope, etc. (toward or away from)

magnitude - constant along the string (but variable in general)

Often talk about flexible, massless strings because the magnitude of the force exerted at any point along the rope is the same for a massless rope.

If the mass of the string, m_2, is not zero, then the force will vary along the string because $\vec{T} = m\vec{a}$, where m will vary depending on the position along the string. Really want $m_2 << m_1$.



(C) Normal Forces ($\vec{N}$)

A normal force is the force exerted across a contact boundary.

A normal force can only push on an object (not pull it) and it is associated with atomic interactions at the boundary.

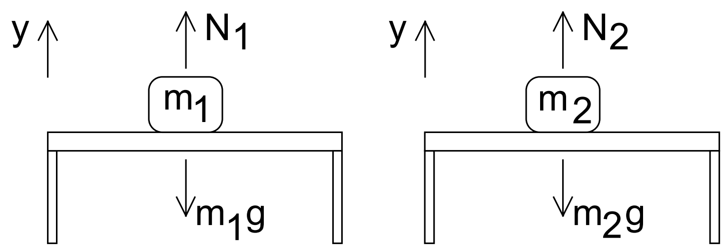
direction - perpendicular to and towards the object

magnitude - variable (depends on what the surface is opposing)

By Newton's Second Law:

$N_1 - m_1 g = m_1 a_y = 0$ $\quad$ $N_2 = m_2 g$

$N_1 = m_1 g$ $\quad$ $N_1 \neq N_2$



Section III.4 Applying Newton's Laws

We will apply the equation $\vec{F}_{net} = m\vec{a}$, breaking it into x, y, z components.

$$\boxed{F_{x,net} = ma_x \quad F_{y,net} = ma_y \quad F_{z,net} = ma_z}$$

Steps in solving problems using Newton's Second Law:

(1) Identify the object or objects in question $\rightarrow$ draw them.

(2) Identify the forces acting on the object(s) $\rightarrow$ draw them in vector form.

(3) Set up a coordinate system for each object $\rightarrow$ can be different for each.

(4) Solve the equation $\vec{F}_{net} = m\vec{a}$, treating the x, y, and z components independently using $F_{x,net} = ma_x, F_{y,net} = ma_y, F_{z,net} = ma_z$.