Lecture 5 Note - *Particles in Equilibrium*

Textbook Chapter 3

What is equilibrium of a particle?:

- Particles are entities that have mass but trivial size
- Therefore, particle equilibrium is the situation of a particle being acted upon by multiple forces, and yet NOT accelerating; the particle is in equilibrium.
  Naturally the sum/resultant of all forces is zero. $\boldsymbol{F} = \sum \boldsymbol{F_x} + \sum \boldsymbol{F_y} + \sum \boldsymbol{F_z} = 0$
- If a particle is in 2D equilibrium, we can solve up to 2 unknown forces acting on it (plus gravity). If a particle is in 3D equilibrium, we can solve up to 3 unknowns (plus gravity).

How to analyze a 2D force equilibrium problem:

- Draw the x and y axes (and define which way is positive)
- Draw a FBD, fill in all forces (known and unknown) with magnitudes and direction
- Resolve (write equations for) forces in the x axis, then the y axis
- Apply equations of equilibrium (eg. sum of the component forces in the x-axis equals 0)
  - Assume a positive direction when writing your equation of equilibrium, i.e. all forces should be in a positive direction (reverse vector arrow if needed)
  - You should get a ratio of forces, i.e. $T_{BA} = (0.1)T_{BC}$, to plug into the next equation
- Solve the equations to get the unknown forces
- Redraw FBD with all forces as positive numbers

3D force equilibrium problems:

- Same as 2D but with a Z axis — you can solve up to 3 forces in equilibrium instead of 2.
- Find each position vector, then divide by their magnitudes to get the unit vectors…

Side note: How to draw FBDs:

- Isolate the particle (object) from its surroundings and draw its outline
  - If the object is a rope, draw it at the same angle as appears in the problem
- Draw in all forces acting upon the object, with magnitude and direction
- Solve for the forces
- *Note: In particle equilibrium, all forces are concurrent: They pass through 1 point*
- *Note: Tension is a pulling force (arrow points away from object rope is attached to).*

Side note: Cables and spring considerations:

- Hooke's law: The force of a spring equals its spring constant times displacement. $F_S = ks$
- Objects in tension "feel" force towards the object pulling them, and vice versa (3rd law)
- Cable weight, stretch, and friction is considered trivial. Cables must be in tension to work
- Pulleys change the direction a rope applies force in.