Phys141 – Mon 9/18

- **Today:**
  - **Finish rotational motion Chapter 4**
  - **Chapter 5**

Administrative:
- **Midterm 1: Oct 4 Mix of conceptual questions and quantitative questions**

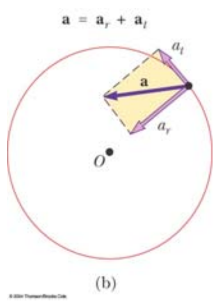
Material up to Chapter 7

- For Wed:
  - **Read: Ch 5.5-8**
  - **Online quiz**

Chapter 4

Total Acceleration

- Change in object speed: *tangential acceleration*
- Change in direction of velocity vector: *radial acceleration*
- *Total acceleration:* Vector sum of radial and tangential acceleration



Chapter 4

Total Acceleration, equations

- The tangential acceleration: $a_t = \frac{d|\mathbf{v}|}{dt}$
- The radial acceleration: $a_r = -a_C = -\frac{v^2}{r}$
- The total acceleration:
  - Magnitude

$$a = \sqrt{a_r^2 + a_t^2}$$

Chapter 4

Total Acceleration, In Terms of Unit Vectors

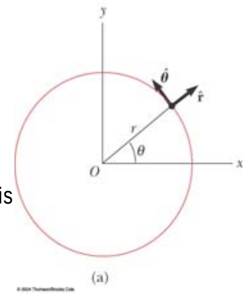
- Define the following unit vectors

  $\hat{\mathbf{r}}$ and $\hat{\theta}$

  r along the radius vector

  θ tangent to the circle
- The total acceleration is

$$\mathbf{a} = \mathbf{a}_t + \mathbf{a}_r = \frac{d|\mathbf{v}|}{dt}\hat{\theta} - \frac{v^2}{r}\hat{\mathbf{r}}$$



CHAPTER 5: Newton's Laws

Newton's first law: *-law of inertia*

An object will resist attempts to change its velocity (objects have *inertia*)

If an object does not interact with other objects, it has zero acceleration.

Note: To apply this law, use frame of reference that does not accelerate *(inertial reference frame)*

Chapter 5

Newton's Second Law

In inertial frame: Force = Mass * acceleration

$F = ma$ Need force to accelerate

Law applies to forces exerted **ON** individual object

$a = \frac{F}{m}$ Larger Mass, less acceleration for same force

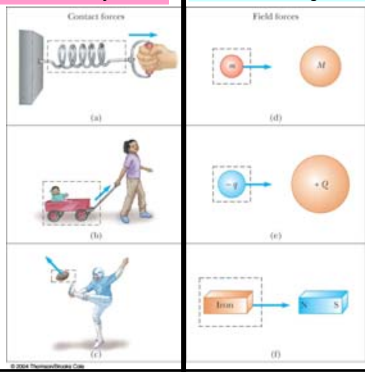
More than one force can be applied to one object: vector sum of all forces yields net force on object!

$$\Sigma \mathbf{F} = ma$$

Units of Force? $kg\frac{m}{s^2}$ Derived units: Newton (N) 1N =1

Contact forces involve physical contact between two objects

Field forces act through empty space – can act over long distance



Fundamental Forces

- Gravitational force
  - Between two objects
- Electromagnetic forces
  - Between two charges
- Nuclear force
  - Between subatomic particles
- Weak forces
  - Arise in certain radioactive decay processes

Forces we deal with in This course

Other forces (including all contact forces) are result of fundamental forces

Examples:

Friction force: Caused by complicated sum of electromagnetic forces between many particles in the two surfaces that rub against each other.

Spring force: Result of electromagnetic forces between atoms in the spring

Force a wall exerts on a ball thrown against the wall: Result of electromagnetic forces between atoms in the ball and wall

Chapter 5

More About Newton's Second Law

$\Sigma \mathbf{F} = m\,\mathbf{a}$

Like any vector equation Newton's Second Law can also be expressed in terms of components:

$\Sigma F_x = m\,a_x$

$\Sigma F_y = m\,a_y$

$\Sigma F_z = m\,a_z$

Chapter 5

Example of separation of Newtons law into components

Equilibrium: Zero Net Force

-> The acceleration is equal to zero

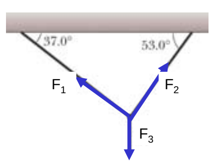
-> The velocity does not change

The object, if at rest, will remain at rest

If the object is moving, it will continue to move in same direction at same speed

$\sum \mathbf{F} = 0$

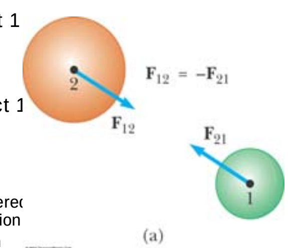
$\sum F_x = 0 \text{ and } \sum F_y = 0$



Chapter 5

Newton's Third Law

The force $\mathbf{F}_{12}$ exerted by object 1 on object 2 is equal in magnitude and opposite in direction to the force $\mathbf{F}_{21}$ exerted by object 2 on object 1



$\mathbf{F}_{12} = -\mathbf{F}_{21}$

Action = reaction

It doesn't matter which is considered the action and which the reaction

Deals with Interactions between TWO objects (unlike Newton's 2nd law which looks at the forces exerted ON one object)

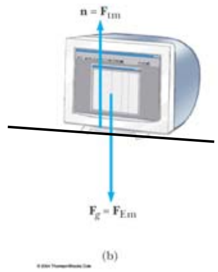
Chapter 5

Free Body Diagram

- Free body diagram: forces acting **on one particular object**

<u>Example: Monitor on table</u>

- Normal force (the table pushing the monitor upward)
- force of gravity (earth pulling the monitor downward)



Chapter 5

Tension in strings

- Apply equilibrium equation (Newton 2nd law) to the light and find $\mathbf{T}_3$
  - Note: Object pulling a rope with a force: the magnitude of that force, **T**, is the **tension** in the rope

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Use Newtons 3rd law: Light pulls on knot with same Magnitude and opposite direction of force as knot pulls on light

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- Apply equilibrium equations to the knot and find $\mathbf{T}_1$ and $\mathbf{T}_2$
- **Remember this week's lab**