IDX G9 Physics H
Study Guide S1 Monthly 2
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Chapter 4: Forces & Equilibrium (Translational Motion)

A. Equilibrium Problems

Translational Equilibrium

Definition:

The object is in **translational equilibrium** if the **net force** acting on an object is **zero.**

Conditions:

- **Object at rest** ($v = 0$)
- **Object moving with constant velocity** ($v \neq 0$, but $a = 0$)

Key idea: equilibrium **doesn't** mean "no motion" — it means **no acceleration**.

Formulas:

$$\sum \vec{F} = 0$$

$$\sum F_x = 0, \sum F_y = 0$$

Not in Translational Equilibrium

If the net force is **not zero**:

$$\sum F \neq 0 \Rightarrow a \neq 0$$

$$\sum F = ma$$

B. Friction Problems

Friction

Definition:

A force that **opposes relative motion** (or attempted motion) between two surfaces in contact.

Types of Friction

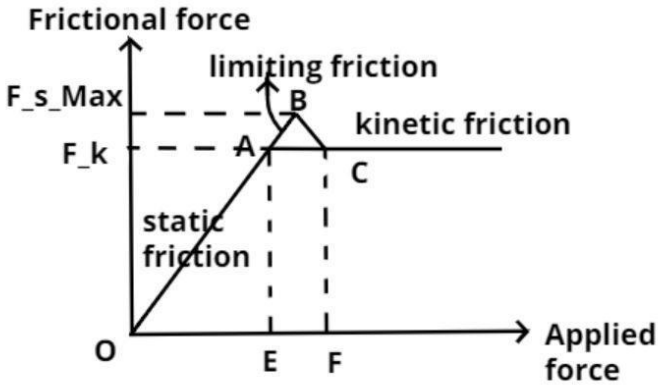
1. **Static friction**
    - Acts when an object is **at rest**
    - Adjusts up to a maximum value

$$f_s \leq f_{s,\,\max} = \mu_s N$$

2. **Kinetic friction**

- Acts when sn object is **sliding**

$$f_k = \mu_k N$$



Normal Force (Important!)

- Perpendicular contact force from a surface
- On a flat surface (no vertical acceleration):

$$N = mg$$

Strategy for Friction Problems

1. Draw a **free-body diagram**
2. Choose +x direction (usually direction of motion)
3. Write:

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

4. Apply:
   - Equilibrium rules (if a = 0)
   - Newton's 2nd Law (if a ≠ 0)

C. Inclined Plane Problems

Forces on an Inclined Plane

- Weight: mg
- Normal force: N
- Friction (if present): fs or fk

Resolving Weight

Weight is split into components:

- **Parallel to plane (Down the Slope):**

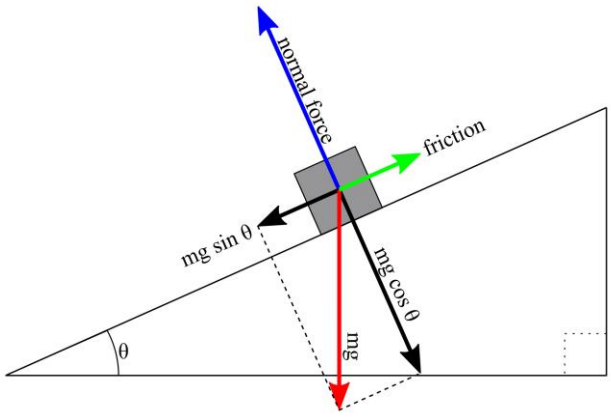
$$\boldsymbol{mg\sin\theta}$$

$$\boldsymbol{f = \mu N = \mu mg\cos\theta}$$

- **Perpendicular to plane:**

$$\boldsymbol{mg\cos\theta}$$

$$\boldsymbol{N = mg\cos\theta}$$



Equilibrium on Inclined Plane

If object is at rest or moving at constant speed:

$$\sum \boldsymbol{F}_{\parallel} = \mathbf{0}$$

D. Connected Objects

1. About Tension

Tension (T):

- Force transmitted via a string, rope, or cable
- Acts **along the string**
- Always pulls **away** from the object

Ideal string & pulley assumptions:

- Massless string
- Frictionless pulley
- Same tension throughout the string

2. System

System:

Any group of **one or more objects** chosen

- Objects inside → **system**
- Everything else → **surroundings**

Choosing the system wisely can **simplify forces and equations**.

3. External Forces

Definition:

Any force acting on the system by an object **outside** the system.

Ex:

- Gravity
- Normal force
- Friction from the ground

4. Internal Forces

Definition:

Forces **between objects inside** the system.

Example:

- Tension between two masses in the same system
-

Key Tip for Connected Objects

- Write **separate equations** for each object **or**
- Write **one equation** for the entire system (tension cancels)

Chapter 1: Introduction, Measurement, Estimating

1.4 Measurement and Uncertainty; Significant Figures

Definitions:

- Measurement: a comparison between an unknown quantity and a standard
- Significant Figures: valid/reliable digits in a measurement
- Estimated/uncertain digit: Last digit in a measurement
- Accuracy: how close a measurement is to the “true value”

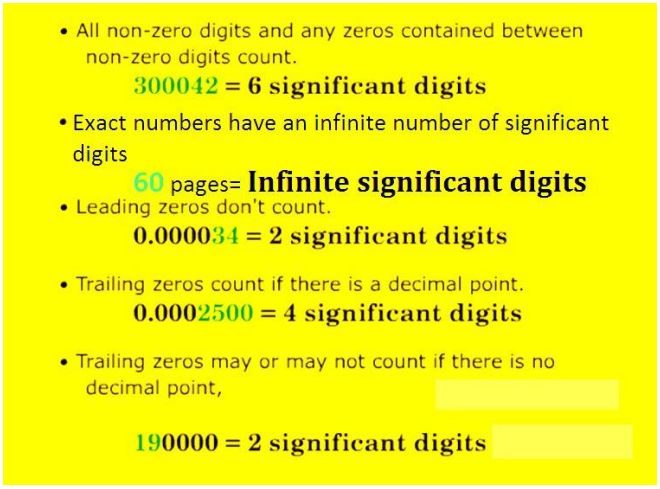
- Precision: the repeatability of the measurement using a given instrument.

Rules for significant digits:

- Trailing zeros may or may not count if there is no decimal point
- For scientific notation, only count the term, since the power doesn't count
- For addition or subtraction:
    - Round the result to have as many decimal places as the measured number with the smallest number of decimal places.
- For multiplication and division
    - Round the result to have as many significant figures (digits) as the measured number with the smallest number of significant figures

Uncertainty

- No measurement made is ever exact
- The accuracy and precision of a measurement are always limited.



- Random errors

- The statistical fluctuations (in either direction) in the measured data due to the precision limitations of the measurement device. Reduced by doing multiple observations and finding the average and devitations
- Least count: the smallest division that is marked on the instrument
- ILE (Instrument limit of error): least count or 1/2 of least count

(Measured value ± uncertainty) unit

- Systematic errors
  - They are reproducible inaccuracies that are consistently in the same direction
- Relative and Absolute Errors
  - Absolute error/ uncertainty Δx: size of error and units
  - Relative (Fractional) uncertainty (often used for precision): $\frac{uncertainty}{measured\ value} = \frac{\Delta x}{x}$
  - Reactive error (often used for accuracy)= $\frac{measured\ value - expected\ value}{expected\ value}$

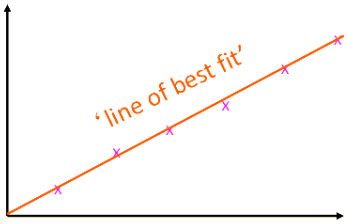
Percentage uncertainty= relative uncertainty x 100%

Percentage error(percentage discrepancy)=relative error x 100%

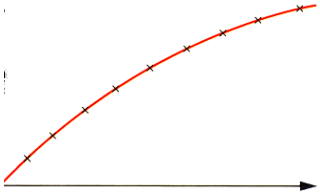
- Propagation of Errors, Basic Rules
  - For addition and subtraction
    - The absolute uncertainty of the final result = the sum of absolute uncertainties
  - For multiplication and division
    - The percent uncertainty of the final result = the sum of percent uncertainties

- For multiplication by an exact number, multiply the uncertainty by the same exact number

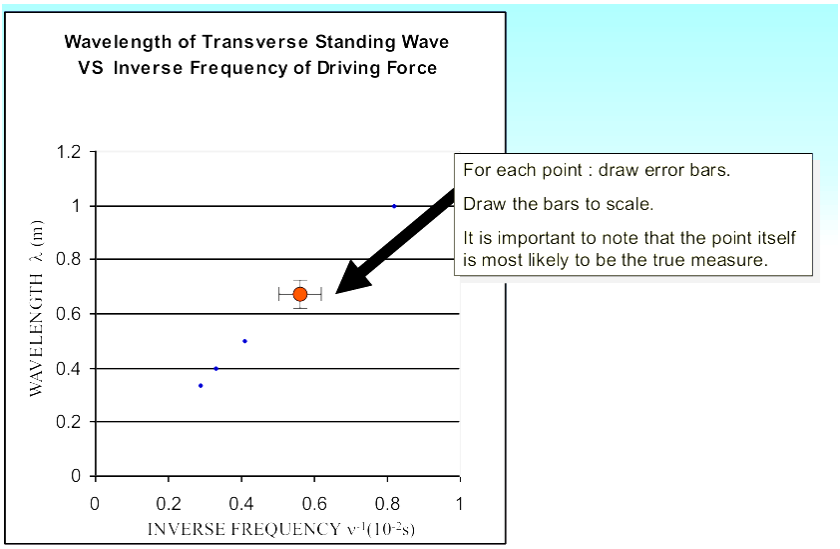
- Graphing
  - After drawing points on graphs using “X”, if the points form a straight linem it is a “line of best fit”:

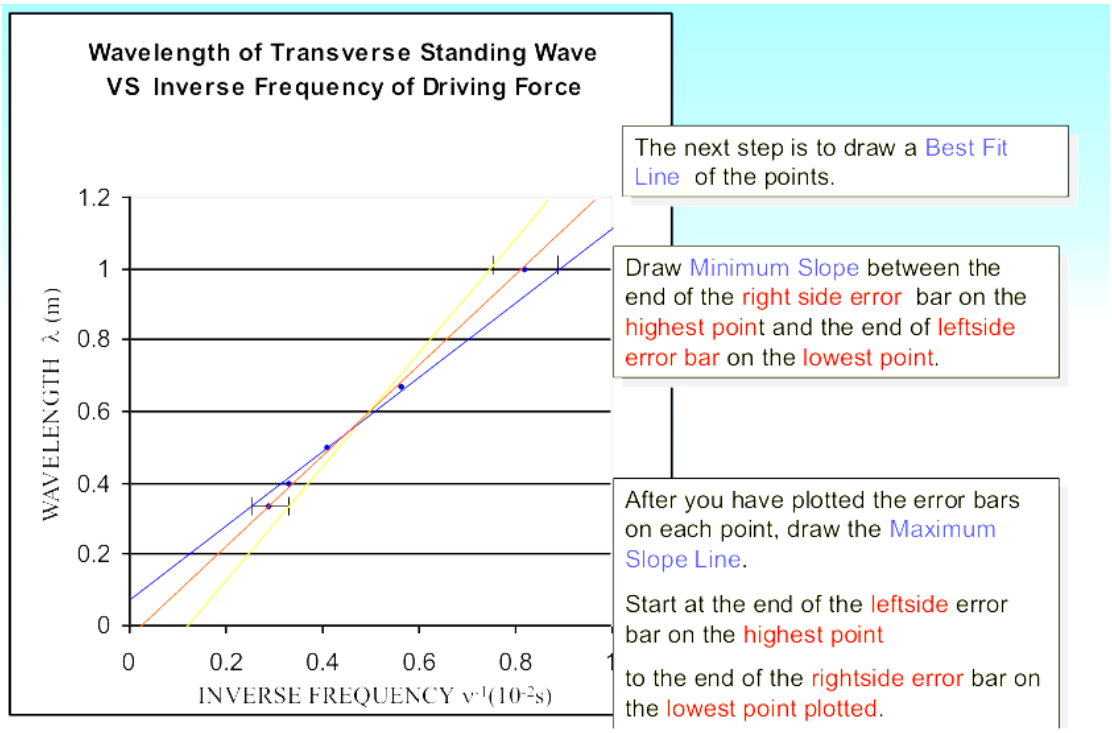


  - After drawing points on graphs using “X”, if the points form a curve, it is a “smooth curve”



  - Graphing with error bars:





1.5 Units, Standards, and the SI System

International System of Units (SI)

SI Base Units

Base Quantity	Name	Symbol
Length	meter	m
Mass	kilogram	kg
Time	second	s
Electric current	ampere	A
Thermodynamic temperature	kelvin	K
Amount of substance	mole	mol
Luminous intensity	candela	cd

SI Derived Units

Derived Quantity	Name	Symbol	Equivalent SI units
Frequency	hertz	Hz	s^{-1}
Force	newton	N	$m{\cdot}kg{\cdot}s^{-2}$
Pressure	pascal	Pa	N/m^2
Energy	joule	J	N·m
Power	watt	W	J/s
Electric charge	coulomb	C	s·A
Electric potential	volt	V	W/A
Electric resistance	ohm	Ω	V/A
Celsius temperature	degree Celsius	°C	K*

*Unit degree Celsius is equal in magnitude to unit kelvin.

SI Prefixes

Factor	Name	Symbol	Numerical Value
10^{12}	tera	T	1 000 000 000 000
10^{9}	giga	G	1 000 000 000
10^{6}	mega	M	1 000 000
10^{3}	kilo	k	1 000
10^{2}	hecto	h	100
10^{1}	deka	da	10
10^{-1}	deci	d	0.1
10^{-2}	centi	c	0.01
10^{-3}	milli	m	0.001
10^{-6}	micro	μ	0.000 001
10^{-9}	nano	n	0.000 000 001
10^{-12}	pico	p	0.000 000 000 001

Adapted from NIST Special Publication 811.
SI rules and style conventions recommend using spaces rather than commas to separate groups of three digits.

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