Gen Physics

Vector and Scalar Quantity:

Vectors

- A vector is a physical quantity that has both magnitude and direction.
- Represented with an arrow above the symbol (→).
- Examples: displacement, velocity, acceleration, force.
- Vectors are multidimensional.

Scalars

- A **scalar** is a quantity that has only **magnitude (size)**.
- It does **not** include direction.
- Fully described by a numerical value.
- Examples: mass, temperature, speed, energy.

Key Difference

- Scalars: **one-dimensional** (only magnitude).
- Vectors: **multi-dimensional** (magnitude + direction).

Scalar	Vector
Has only the magnitude	Has direction and magnitude
Only one-dimensional	Is multidimensional
Changes with the change in magnitude	Changes with magnitude and direction
Normal rules of algebra are applicable	There is a different set of rules known as vector algebra
One scalar quantity can divide another scalar	One vector cannot divide another vector
Example: Speed, time, distance between points	Example: Velocity (rate of change of position)

Standard Deviation

- **Definition:** Measures how spread out data is from the mean.
- **Low SD:** Data points are close to the mean.
- **High SD:** Data points are widely spread out.

Examples:

- Exam scores:
  - Low SD → most students scored similarly.
  - High SD → wide performance gap.
- Weather:

- Consistent temperature = low SD.
- Unpredictable weather = high SD.

$$\sigma = \sqrt{\frac{\sum (x_i - \mu)^2}{N}}$$

σ = population standard deviation

N = the size of the population

x_i = each value from the population

μ = the population mean

For more questions, please refer to this video (not chudai 1000% reyal not fakeh)

How To Calculate The Standard Deviation

Precision and Accuracy

Precision

- How close repeated measurements are to each other.
- Example: Repeated weight readings of 67.5g → precise.

Accuracy

- How close a measurement is to the **true value**.
- Example: If true weight is 6.7g and reading is 6.6g → accurate.

Relationship

1. **High accuracy + High precision:** Best (close to true value & clustered).
2. **High accuracy + Low precision:** Average is right, but measurements vary.
3. **Low accuracy + High precision:** Consistently wrong.
4. **Low accuracy + Low precision:** Worst case.

Estimation of Common Physical Quantities

Estimation Techniques

- Use **reference objects** for comparison.
- Order of magnitude helps simplify very large/small numbers.

Examples

- **Length/Distance:**
  - Adult step ≈ 1 m
  - Door height ≈ 2 m
- **Mass/Weight:**
  - Paperclip ≈ 1 g
  - 1 L water ≈ 1 kg
  - Small car ≈ 1000 kg
- **Time:**
  - “One Mississippi” ≈ 1 second
  - Heartbeat ≈ 1 second
- **Speed:**
  - Walking ≈ 5 km/h
  - Biking ≈ 20–25 km/h
  - Highway car ≈ 100 km/h
  - Passenger plane ≈ 900 km/h

Order of Magnitude

- Expresses scale in powers of 10.
- Example: 2,500,000 g = **2.5×10^6 g** → order of magnitude = **10^6**

Physical Quantities & Measurement

SI Base Quantities

- **Length:** 1 meter = distance light travels in vacuum in 1/299,792,458 s.
- **Time:** 1 second = 9,192,631,770 cycles of microwave radiation in Cesium-133.
- **Mass:** 1 kilogram = mass of platinum-iridium cylinder kept in Sèvres, France.

Conversions

- 1 inch = 2.54 cm
- 1 lb = 4.448 N

Significant Figures

- All nonzero digits are significant.
- Zeroes between nonzero digits are significant.
- Leading zeroes are not significant.
- Trailing zeroes after a decimal are significant.

Scientific Notation

- Expresses numbers as a product of a number (1–9) and a power of 10.
- Example: 2,500 = **2.5×10^3**

Velocity and Speed

Speed vs. Velocity

Speed: distance traveled per unit time. Scalar quantity.

Formula: $$\text{Speed} = \frac{\Delta d}{\Delta t}$$ **(Formulas)**

Unit: m/s

Velocity: speed with direction (vector).

Formula:

$$\text{Velocity} = \frac{\text{Displacement}}{\text{Time}}$$

Average Speed:

$$v_{avg} = \frac{\text{Total distance}}{\text{Total time}}$$

Average Velocity:

$$v_{avg} = \frac{\text{Total displacement}}{\text{Total time}}$$

Example Problems

1. **Man walking 7 km in 2 hr, then 2 km in 1 hr (same direction):**
   - Average speed = $\frac{9}{3} = 3 \text{ km/hr}$
   - Average velocity = $\frac{9}{3} = 3 \text{ km/hr}$
2. **Bus traveling at 40 km/h for 4.5 h:**

   Distance = $v \times t = 40 \times 4.5 = 180\,\text{km}$
3. **Practice problems given:**
   - Bird flying 250 miles in 5 h → average speed
   - Cyclist displacement 100 km south in 25 h → average velocity
   - Jeepney: $v = 10\,\text{m/s}, t = 2.5\,\text{s}$ → distance = 25 m

Acceleration

- **Definition: Rate of change of velocity. Vector quantity.**
  Unit: m/s²

$$a = \frac{\Delta v}{\Delta t} = \frac{v_f - v_i}{t_f - t_i}$$

(Formula)

Example Questions:

1. Car from rest to 80 m/s in 5s:

$$a = \frac{80 - 0}{5} = 16\,\mathrm{m/s^2}$$

2. Coaster from 10 m/s to 26 m/s in 2s:

$$a = \frac{26 - 10}{2} = 8\,\mathrm{m/s^2}$$

3. Racehorse: rest → 15 m/s west in 3s:

$$a = \frac{15 - 0}{3} = 5\,\mathrm{m/s^2}\,(\mathrm{west})$$

Distance and Displacement

Distance vs. Displacement

- **Distance**: total ground covered (scalar).
- **Displacement**: overall change in position (vector).

🔹 Speed and Velocity

- **Speed** (scalar):

$$v = \frac{d}{t}$$

- **Velocity** (vector):

$$v = \frac{\Delta x}{t}$$

    - Speed = |velocity|
    - Example: 45 m/s (speed), 30 m/s west (velocity)

- **Average Speed**:

$$v_{avg} = \frac{d}{t}$$

- **Average Velocity**:

$$v_{avg} = \frac{\Delta x}{t}$$

(Formulas)