

# Checking units, uncertainties and vector components

Physics grades 11-12 (A Level · IB · Class 11-12) · Worksheet

Name: \_\_\_\_\_ Date: \_\_\_\_\_ Class: \_\_\_\_\_

These problems train the three habits behind every quantitative physics answer: checking units, stating how reliable a measurement is, and splitting directional quantities into components. You will convert units, test equations for homogeneity, combine uncertainties and resolve and add vectors.

They are written for 16 to 18 year olds following A Level, IB Physics, CBSE Class 11-12 or similar senior courses. Work from level 1 to level 3, show every substitution and always attach a unit.

**Level:** Physics grades 11-12 (A Level · IB · Class 11-12) · **Curriculum:** A Level 1, IB A

## Problem 1 Base units (easy)

Aarav in Pune is revising SI units.

1. Write the newton in base units.
2. Write the joule in base units.
3. Write the watt in base units.

## Problem 2 Prefix conversions (easy)

Convert each quantity to the SI unit shown.

1. 4.5 mm to m
2. 72 km/h to m/s
3. 0.25 g/cm<sup>3</sup> to kg/m<sup>3</sup>
4. 1.2 GW to W

## Problem 3 Scalar or vector (easy)

Classify each quantity as a scalar or a vector.

1. Speed
2. Displacement
3. Kinetic energy
4. Force
5. Time

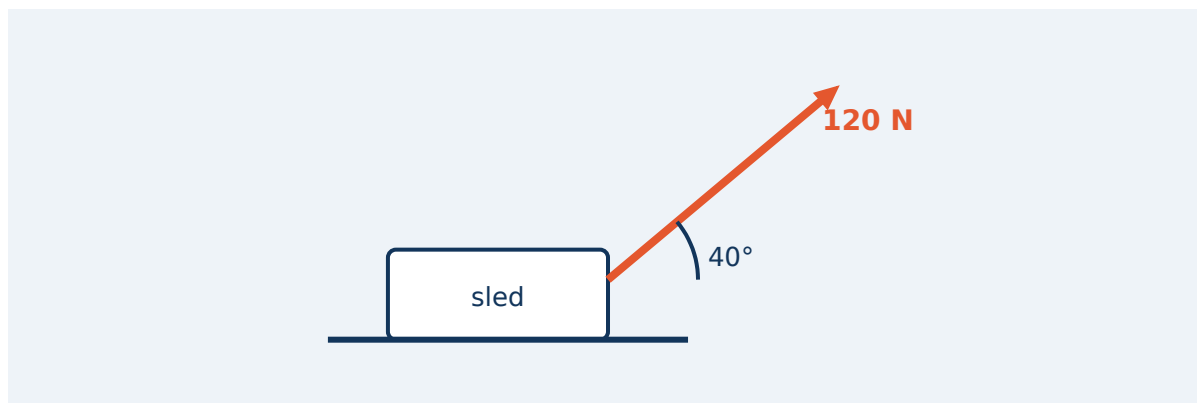
## Problem 4 Percentage of one reading (easy)

Chiamaka in Lagos measures a leaf with a ruler and times a falling seed with a stopwatch.

1. The leaf is 24.3 cm long with an uncertainty of  $\pm 0.1$  cm. Calculate the percentage uncertainty.
2. The seed takes 1.6 s to fall with an uncertainty of  $\pm 0.2$  s. Calculate the percentage uncertainty.

### Problem 5 Components of a pull (easy)

Wanjiru in Nairobi pulls a sled with a rope that makes  $40^\circ$  with the ground and carries a tension of 120 N.



*The rope pulls at  $40^\circ$  above the horizontal.*

1. Calculate the horizontal component of the force.
2. Calculate the vertical component of the force.

### Problem 6 Spot the wrong equation (easy)

A student writes  $v = u + at^2$  for the final speed of a trolley.

1. Write the base units of each term.
2. State why the equation cannot be correct.

### Problem 7 Check $v^2 = u^2 + 2as$ (medium)

Emma in Leeds wants to confirm a standard equation.

1. Write the base units of  $v^2$ ,  $u^2$  and  $2as$ .
2. State whether the equation is homogeneous.

### Problem 8 Unit of a drag constant (medium)

Diego in Texas models air drag on a ball with  $F = kv^2$ , where  $F$  is in newtons and  $v$  is in  $\text{m s}^{-1}$ .

1. Rearrange for  $k$ .
2. Find the base units of  $k$ .

### Problem 9 Sum and difference (medium)

Two metal rods are measured as  $15.2 \pm 0.1$  cm and  $8.7 \pm 0.1$  cm.

1. Calculate the length of the two rods end to end, with its absolute uncertainty.
2. Calculate the difference in length, with its absolute uncertainty.
3. Compare the percentage uncertainties of the two results.

### Problem 10 Area of a garden (medium)

Mei measures a rectangular school garden as  $45.0 \pm 0.5$  m by  $30.0 \pm 0.5$  m.

1. Calculate the percentage uncertainty in each length.
2. Calculate the area and its absolute uncertainty.

### Problem 11 Speed with uncertainty (medium)

Kofi in Accra times a sprinter:  $100.0 \pm 0.5$  m is covered in  $12.5 \pm 0.1$  s.

1. Calculate the average speed.
2. Calculate the percentage uncertainty in the speed.
3. State the speed with its absolute uncertainty.

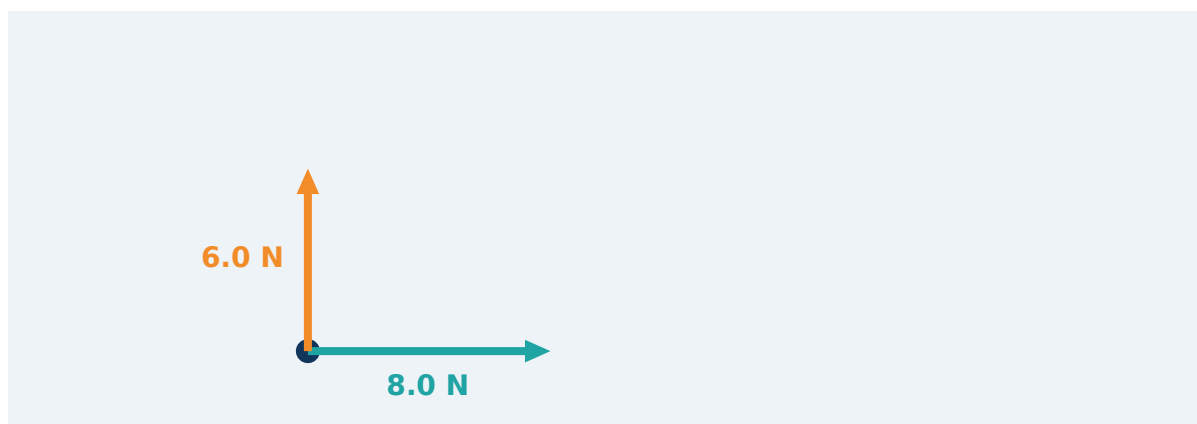
### Problem 12 Volume of a sphere (medium)

A glass marble has a radius of  $2.50 \pm 0.05$  cm. The volume is  $V = (4/3)\pi r^3$ .

1. Calculate the volume.
2. Calculate the percentage uncertainty in the radius.
3. Calculate the percentage and absolute uncertainty in the volume.

### Problem 13 Perpendicular forces (medium)

Bilal in Lahore pulls a crate with two ropes at right angles to each other.



*The two forces are perpendicular.*

1. Calculate the magnitude of the resultant force.
2. Calculate the angle between the resultant and the 8.0 N force.

### Problem 14 Suitcase handle (medium)

Aarav pulls a suitcase with a force of 55 N along the handle, which makes  $28^\circ$  with the horizontal.

1. Calculate the horizontal component.
2. Calculate the vertical component.
3. State what the vertical component does to the push of the suitcase on the floor.

### Problem 15 Repeated timings (medium)

Chiamaka times five swings of a playground swing: 2.31 s, 2.35 s, 2.29 s, 2.33 s, 2.32 s.

1. Calculate the mean time.
2. Estimate the absolute uncertainty using half the range.
3. Calculate the percentage uncertainty.

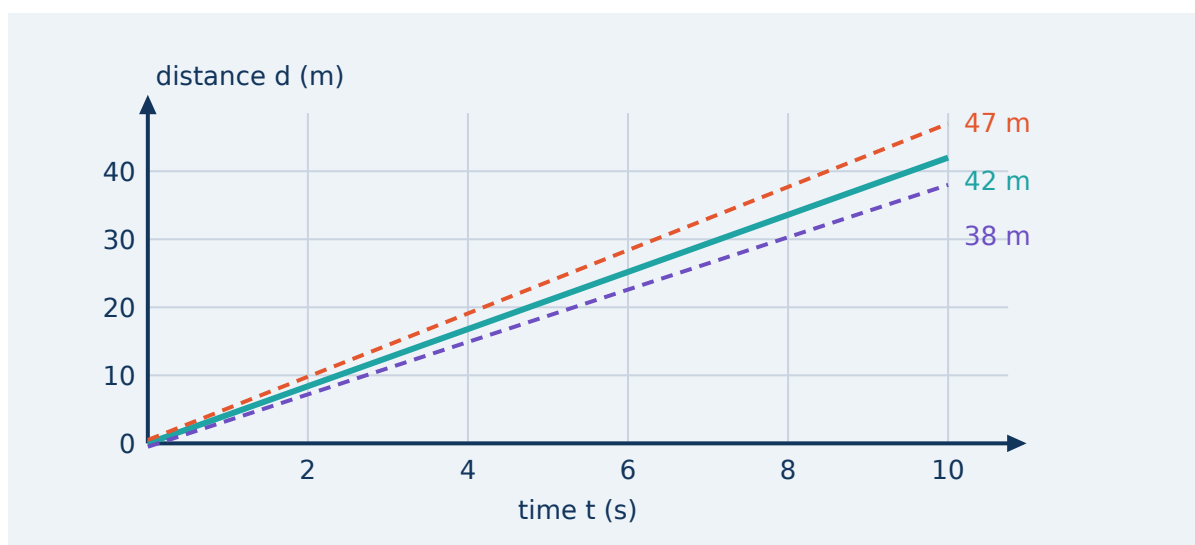
### Problem 16 Finding g with a pendulum (hard)

Emma finds g using  $g = 4\pi^2 L \div T^2$ . She measures  $L = 0.840 \pm 0.002$  m and  $T = 1.84 \pm 0.02$  s.

1. Calculate g.
2. Calculate the percentage uncertainty in L and in T.
3. Calculate the percentage and absolute uncertainty in g.
4. State g with its uncertainty.

### Problem 17 Gradient uncertainty (hard)

Kofi plots the distance of a cyclist against time. The best-fit line runs from (0, 0) to (10.0 s, 42 m). The steepest line through the error bars runs from (0, 0.5 m) to (10.0 s, 47 m). The shallowest runs from (0, -0.5 m) to (10.0 s, 38 m).



*Best, steepest and shallowest lines.*

1. Calculate the three gradients.
2. Calculate the uncertainty in the speed.
3. State the speed with its uncertainty.

### Problem 18 Two tugs on a barge (hard)

Two tugs pull a barge. Tug A pulls 500 N due east. Tug B pulls 350 N at 60° north of east.

1. Calculate the total eastward component.
2. Calculate the total northward component.
3. Calculate the magnitude of the resultant force.
4. Calculate its direction north of east.

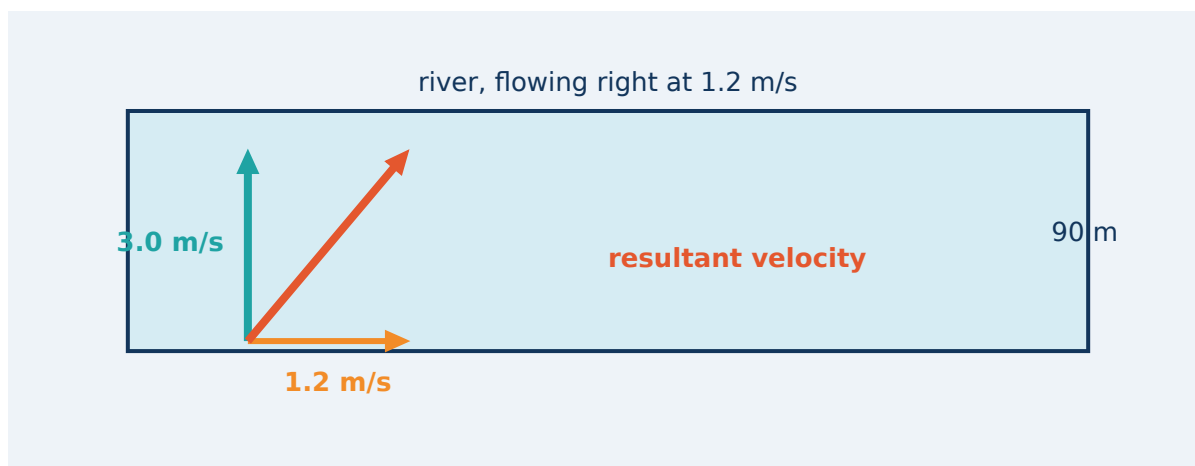
### Problem 19 Dimensional analysis (hard)

Bilal suspects that the force needed to keep a car on a circular bend depends on the car's mass  $m$ , its speed  $v$  and the radius  $r$  of the bend:  $F = k m^a v^b r^c$ , where  $k$  has no units.

1. Write the base units of  $F$ ,  $m$ ,  $v$  and  $r$ .
2. Equate the powers of kg, m and s on both sides.
3. Find  $a$ ,  $b$  and  $c$  and write the equation.

### Problem 20 Crossing a river (hard)

Diego's boat heads straight across a river 90 m wide at 3.0 m/s relative to the water. The current flows at 1.2 m/s.



*The boat is carried downstream while it crosses.*

1. Calculate the time to cross.
2. Calculate how far downstream the boat lands.
3. Calculate the magnitude of its velocity relative to the bank.
4. Calculate the angle between its path and the straight line across.