5.1 Scalars, vectors and forces

Name: _____ Class: _____ Date: _____ **Total: 22 marks**

KEY WORDS scalar • vector • contact • non-contact • weight • centre of mass • resultant force

Objective

Classify scalars and vectors, contact and non-contact forces, calculate weight, and find collinear resultants; (HT) use free-body diagrams. Original questions for spec statements 4.5.1.1–4.5.1.4.

1 Key knowledge and worked examples

Type	Has direction?	Examples
scalar	no	distance, speed, mass, energy, time
vector	yes	displacement, velocity, force, weight, momentum

A vector is an arrow: **length = magnitude, direction = direction**.

Force type	Objects touching?	Examples
contact	yes	friction, air resistance, tension, normal contact force
non-contact	no	gravitational, electrostatic, magnetic

Weight: $F_W = mg$, acting at the **centre of mass** , measured with a calibrated spring-balance (newtonmeter). Weight $\propto$ mass.

Resultant force : one force with the same effect as all the originals. Collinear rule:

Situation	Resultant
two forces same direction	add: $F_{\text{res}} = F_1 + F_2$
opposite directions	subtract: $F_{\text{res}} = F_1 - F_2$ (direction of the bigger)
equal and opposite	zero – balanced

(HT) **Free-body diagram** : only the forces acting **on** the chosen object, as arrows from its centre. Resolve a force into perpendicular components; find resultants by scale drawing (state the scale).

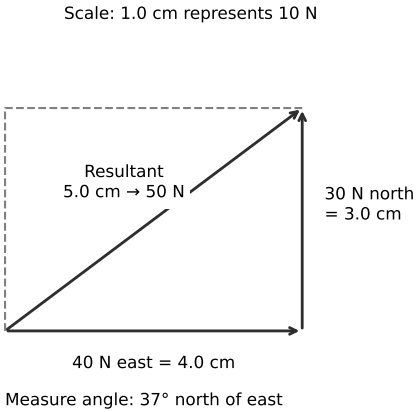
Worked example. A crate is pulled east with 80 N while friction pulls west with 30 N.

- Opposite directions: subtract.

$$F_{\text{res}} = 80 - 30 = 50 \text{ N (east)}$$

Worked example. A 65 kg person stands where $g = 3.7$ N/kg.

$$F_W = mg = 65 \times 3.7 = 240 \text{ N (2 s.f.)}$$



2 Practice

2.1 Sort into scalars and vectors: speed, displacement, mass, weight, energy, acceleration. [2]

2.2 Give one contact and one non-contact force acting on a book resting on a table. [2]

2.3 A box is pushed with 45 N east and 30 N east. State the resultant. A second box gets 45 N east and 30 N **west**. State that resultant. [2]

3 Exam-style questions

3.1 A car tows a caravan. At one instant the caravan pulls back on the car with a tow-bar force of 900 N and the car's driving force is 2100 N. Neglect other horizontal forces on the car for parts (a) and (b).

(a) Calculate the resultant force on the car. [2]

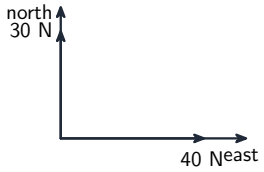
(b) (HT) Draw a free-body diagram of the caravan showing the horizontal forces named. [2]

(c) Later, the driving force is adjusted so the car and caravan travel at a steady velocity. State what this shows about the resultant force and the resistive forces. [2]

3.2 Two forces act at right angles on a small boat: 30 N north and 40 N east (HT).

(a) Use a scale drawing to find the magnitude and direction of the resultant. State your scale. [4]

(b) Without a drawing, state the size of the equilibrant needed to balance the boat. [1]



3.3 An aeroplane travelling in a straight line at constant velocity in level flight has a forward thrust of 12 kN, drag of 12 kN, weight of 60 kN.

(a) State the resultant force on the aeroplane. [1]

(b) Name the fourth force and its size. [2]

(c) (HT) The plane turns in a circle at constant speed. Explain why its velocity is changing. [2]