RESULTANT FORCE

1 Two students make the statements about acceleration that are given below.

Student A: For a given mass the acceleration of an object is proportional to the resultant force applied to the object.

Student B: For a given force the acceleration of an object is proportional to the mass of the object.

(a) One statement is correct and one is incorrect.

Re-write the incorrect statement, making changes so that it is now correct.

For a given ..... the acceleration of an object is .....

..... [1]

(b) State the equation which links acceleration *a*, resultant force *F* and mass *m*.

[1]

(c) Describe what happens to the motion of a moving object when

(i) there is no resultant force acting on it,

..... [1]

(ii) a resultant force is applied to it in the opposite direction to the motion,

..... [1]

(iii) a resultant force is applied to it in a perpendicular direction to the motion.

..... [1]

[Total: 5]

MARKING SCHEME:

(a) 2nd statement re-written to include force in first gap and inversely proportional to mass in second gap. NOT indirectly proportional — B1

(b) F = ma OR in words in any correct arrangement — B1

(c) **(i)** nothing OR continues as before OR same / constant velocity OR same / constant speed & direction OR no acceleration — B1

(ii) idea of retardation. Ignore stop. Ignore brakes. Ignore goes in opposite direction — B1

(iii) moves in (arc of a) circle or curve OR deflected OR turns OR changes direction — B1 [5]

2 **(a)** Fig. 3.1 shows an oil can containing only air at atmospheric pressure.

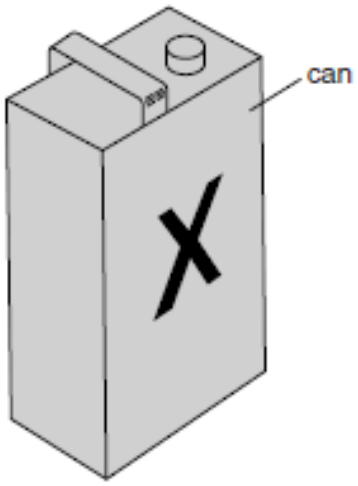

Fig. 3.1

Atmospheric pressure is 1.0×10^5 Pa.

The pressure of the air in the can is reduced by means of a pump. The can collapses when the pressure of the air in the can falls to 6000 Pa.

(i) Explain why the can collapses.

.....

.....[1]

(ii) The surface area of face X of the can is $0.12\,m^2$.

Calculate the resultant force on face X when the can collapses.

force = ...[3]

MARKING SCHEME

(a)	**(i)**	force / pressure greater on outside surface owtte	B1
	(ii)	$p = F/A$ in any form **OR** $(F =)\ pA$	C1
		$= (1.0 \times 10^5 - 6000) \times 0.12$	C1
		11280 N to at least 2 sig. figs.	A1
(b)	**(i)**	pressure of oil = pressure of water	B1
	(ii)	**1.** $(p=)\ h\rho g$	C1
		$(= 0.25 \times 1000 \times 10 =)$ 2500 Pa	A1
		2. $h\rho g = 2500$	C1
		$(\rho = 2500/(0.32 \times 10) =)$ 781 kg / m^3 to at least 2 sig. figs.	A1

[Total: 9]

3 **(a)** **(i)** Mass is a scalar quantity.

State another scalar quantity.

.....

(ii) Force is a vector quantity.

State another vector quantity.

.....

[2]

(b) A boat is floating on still water.

The mass of the boat is 290 000 kg. A resultant force of 50 kN acts on the boat.

Calculate the acceleration of the boat.

acceleration = ...[3]

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The mass of the boat is 290 000 kg. A resultant force of 50 kN acts on the boat.

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(c) Fig. 2.1, not to scale, shows the view from above of the boat, now on a fast-flowing river. The boat accelerates.

Two forces are shown acting on the boat. The resultant of these forces is at right angles to the river banks.

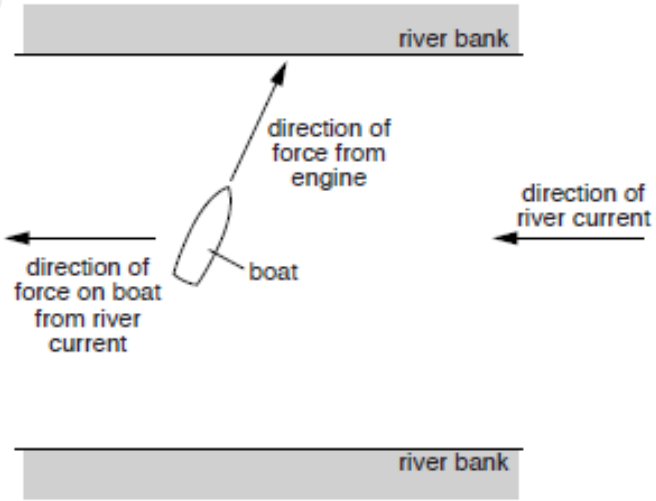

Fig. 2.1 (not to scale)

Fig. 2.2 is an incomplete vector diagram of the forces acting on the boat.

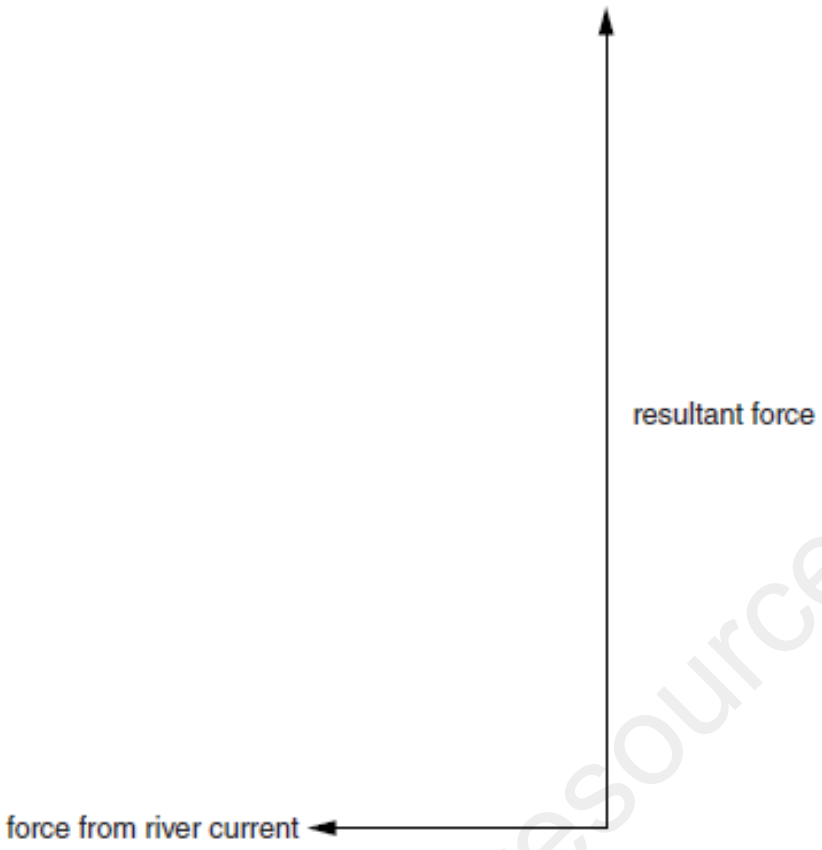

Fig. 2.2

The force from the river current is 80 kN.

(i) Determine the scale that has been used in the vector diagram.

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scale is .....

(ii) On Fig. 2.2, complete the vector diagram to determine the magnitude and direction of the force from the engine. Measure the angle between the direction of the current and the force from the engine.

magnitude of force from engine = ...

angle = ...

[4]

[Total: 9]

MARKING SCHEME:

(a)	**(i)**	any scalar quantity other than mass	B1
	(ii)	any vector quantity other than force	B1
(b)		F = ma in any form OR (a =) F / m	C1
		50 000 / 290 000 OR 50 / 290	C1
		$a = 0.17\ m/s^2$	A1
(c)	**(i)**	1 cm: 20 000 N / 20 kN	B1
	(ii)	triangle completed	B1
		230 000 N OR 230 kN in range 220 000 N – 240 000 N / 220 kN – 240 kN	B1
		by calculation: 110°	
		OR by measurement: 108° – 112°	B1

[Total: 9]

4 Fig. 2.1 shows a tanker lorry full of liquid.

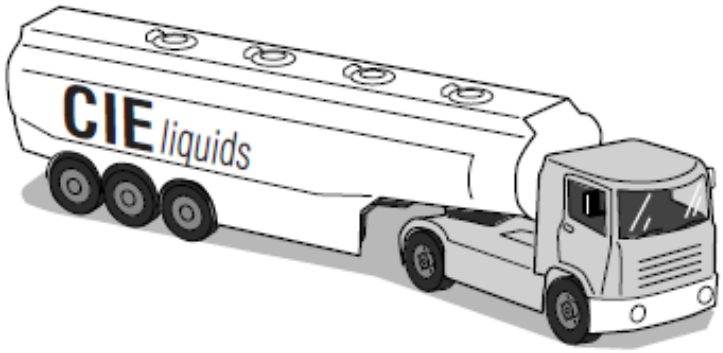

Fig. 2.1

The tanker delivers the liquid and drives away empty.

(a) (i) Compare the acceleration of the empty tanker with the acceleration of the full tanker for the same resultant force. Tick **one** box.

- ☐ acceleration of full tanker is less than acceleration of empty tanker
- ☐ acceleration of full tanker is the same as acceleration of empty tanker
- ☐ acceleration of full tanker is more than acceleration of empty tanker

[1]

(ii) Explain your answer.

.....

.....

.....

..... [2]

(b) The empty tanker has a weight of 50000 N. The forward force is 6000 N and the total resistive force is 2000 N.

Calculate the acceleration.

acceleration = ... [3]

[Total: 6]

MARKING SCHEME:

(a)	**(i)**	less (1st box ticked)	B1
	(ii)	any mention of mass/inertia	B1
		well-reasoned explanation involving less mass	B1
		special case B2: more weight/heavier **AND** more friction	
(b)		(resultant force =) 4000 N	C1
		(M = 50 000/10 =) 5000 kg	C1
		(a = 4000/5000 =) 0.80 m/s^2 e.c.f previous lines, accept 1 sig. fig.	A1
			[Total: 6]

5 **(a)** Fig. 4.1 shows a top view of a tourist vehicle in a game park and two elephants pushing against the vehicle. The two forces indicated are at right angles to each other.

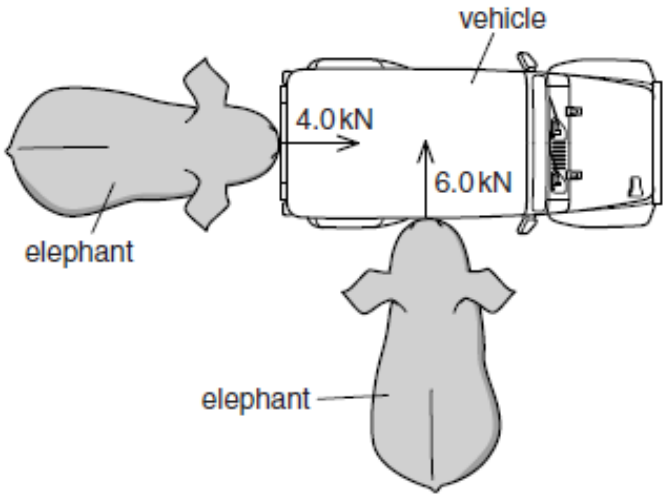

Fig. 4.1

In the space below, draw a scale vector diagram to determine the magnitude of the resultant force. Label the two forces applied and the resultant, and clearly state the scale you use.

magnitude of resultant force = ...[3]

(b) Fig. 4.2 shows another elephant pushing horizontally against a vehicle with a force of 11 kN at a distance 1.8 m above the ground. Point M is the centre of mass of the vehicle.

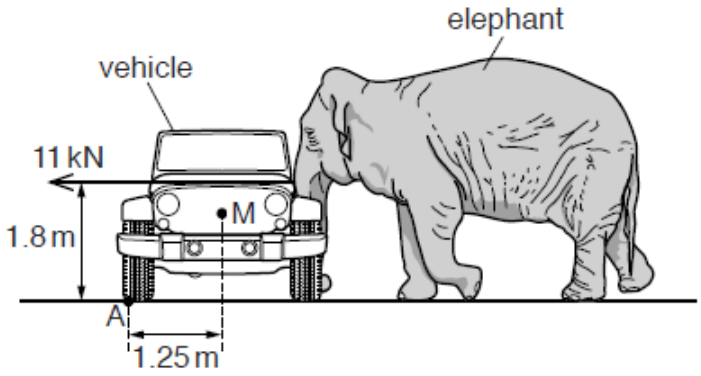

Fig. 4.2

(i) Calculate the moment about point A of the force exerted by the elephant.

moment = ...[2]

(ii) The mass of the vehicle is 1900 kg, and it does not slide when pushed by the elephant.

Determine whether the elephant tips the vehicle over. Show your working.

calculation

conclusion .....[2]

[Total: 7]

MARKING SCHEME:

(a)		2 vectors correct direction AND relative length by eye	B1
		correct triangle OR rectangle with resultant on correct diagonal	B1
		7.2 kN tolerance 7.0 – 7.4 kN	B1
(b)	**(i)**	(moment =) force × distance	C1
		(moment = 11 000 × 1.8 =) 20 kNm	A1
	(ii)	(moment of weight = 19 000 x 1.25 =) 24 (kNm)	B1
		correct statement based on <u>two moments seen</u>	B1
			[Total: 7]