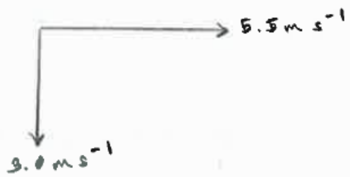
Assignment 02: Scalars and Vectors (compiled student answers)

1. A spacecraft landing on the moon has a vertical velocity of 3.0 m s^{-1} towards the surface. At the same time, it has a horizontal velocity of 5.5 m s^{-1} to the right. At what resultant velocity V does the vehicle move along the descent path? Use a suitable scale diagram to determine the resultant velocity. [4]

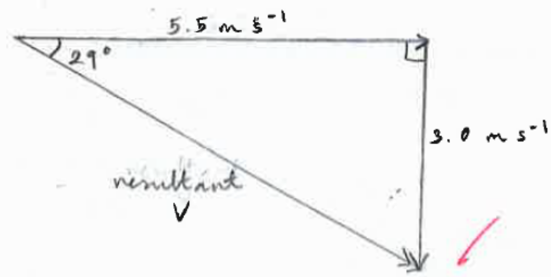
Sketch:



Credit: Nathan Wong, 3I2

[1] Scale: 1.0 cm represents 1.0 m s^{-1}

[1] Vector diagram (to scale):



[1] Magnitude of resultant V = $6.3\ \text{cm} \times 1.0\ \text{m s}^{-1}/\text{cm}$
$= 6.3\ \text{m s}^{-1}$

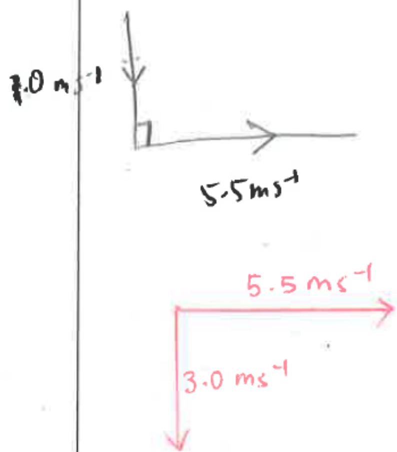
Accept 6.1 m s^{-1} to 6.5 m s^{-1}

[1] Direction of resultant V = 29° clockwise from 5.5 m s^{-1} vector

Accept 27° to 31° clockwise from 5.5 m s^{-1} vector

Alternative solution:

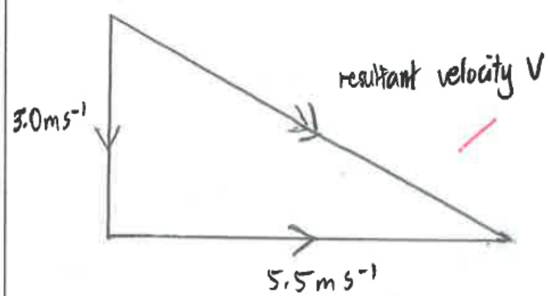
Sketch:



Credit: Tang Zixuan, 3P3

[1] Scale: 1.0 cm represents 1.0 m s^{-1}

[1] Vector diagram (to scale):



[1] Magnitude of resultant V = 6.2 cm × 1.0 m s^{-1}/cm

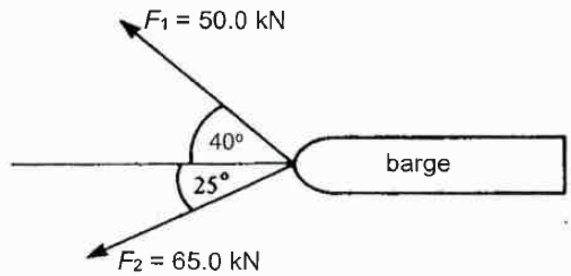
= 6.2 m s^{-1}

Accept 6.1 m s^{-1} to 6.5 m s^{-1}

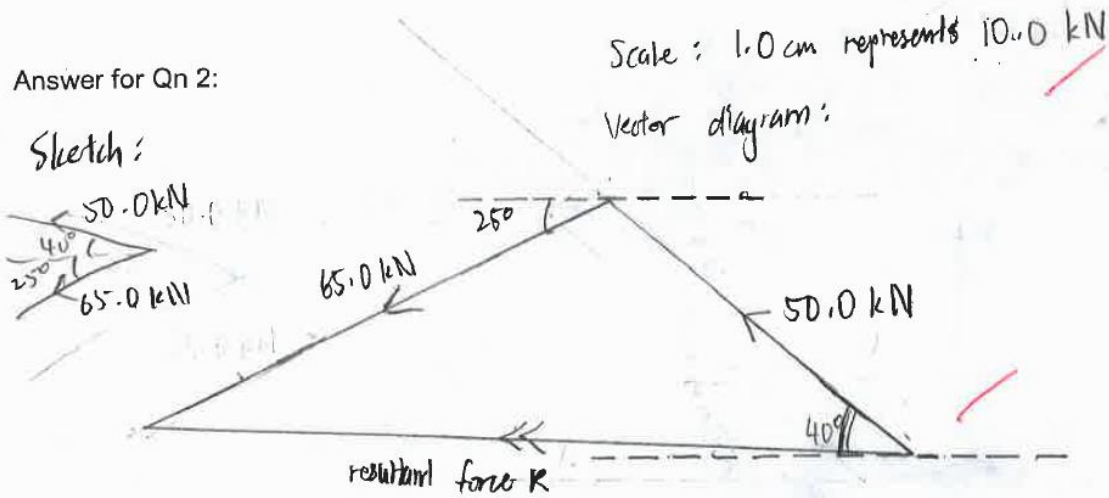
[1] Direction of resultant V = 59° anticlockwise from 3.0 m s^{-1} vector

Accept 59° to 63° anticlockwise from 3.0 m s^{-1} vector

2. The diagram shows the top view of a barge being pulled through still water by two cables. F_1 and F_2 are the forces in the cables which act on the barge. By means of a suitable scale diagram, determine the resultant force R exerted on the barge under the action of forces F_1 and F_2. [4]



Answer for Qn 2:



magnitude of resultant R = 9.7 cm × 10.0 kN/cm
= 97 kN

Accept 95 kN to 99 kN

direction of R = 37° anticlockwise from 50.0 kN vector

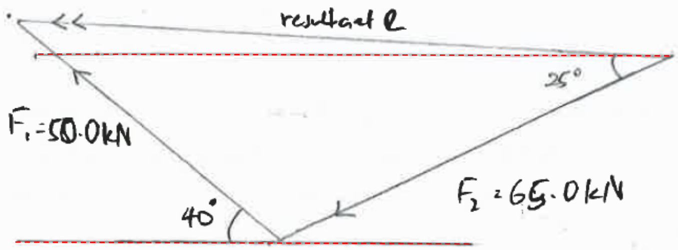
Accept 35° to 39° anticlockwise from 50.0 kN vector

Credit: Tang Zixuan, 3P3

Alternative solution:

Answer for Qn 2:

Scale: 1.0 cm represents 10.0 kN



$9.6 \times 10.0 = 96.0$

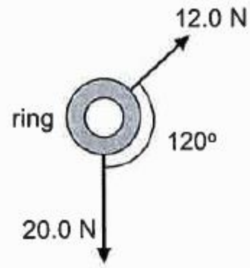
Accept 95 kN to 99 kN

Force R acts at a magnitude of 96.0 kN in the direction 28° clockwise from the 65.0 kN vector.

Accept 26° to 30° <u>clockwise</u> from 65.0 kN vector

Credit: Ong Jun Xi, 3I4

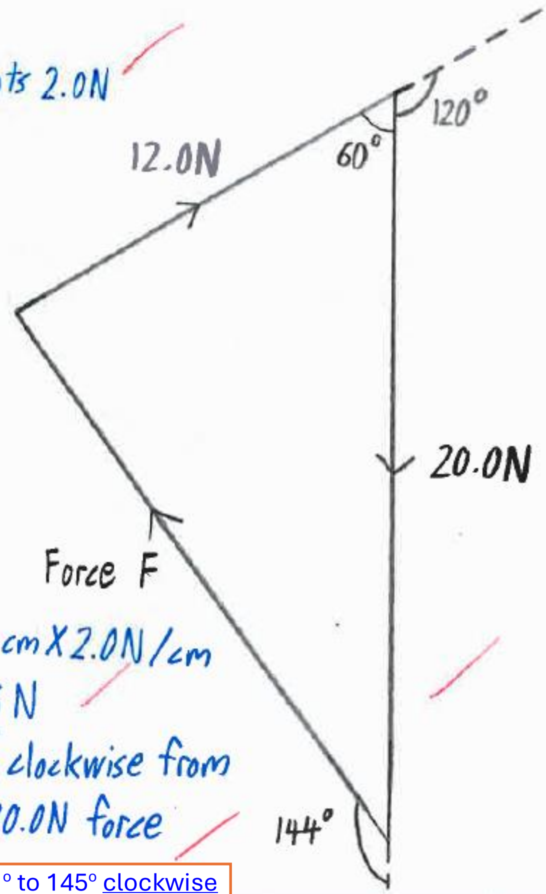
3. The diagram shows the top view of two forces 12.0 N and 20.0 N acting on a metal ring and having an angle of 120° subtended between them.



When a third force F is applied on the ring, it is in equilibrium under the action of the three forces.

Use a suitable scale diagram to determine the force F. [4]

Scale: 1.0 cm represents 2.0 N



Accept 16.8 N to 18.4 N (17 N to 18 N)

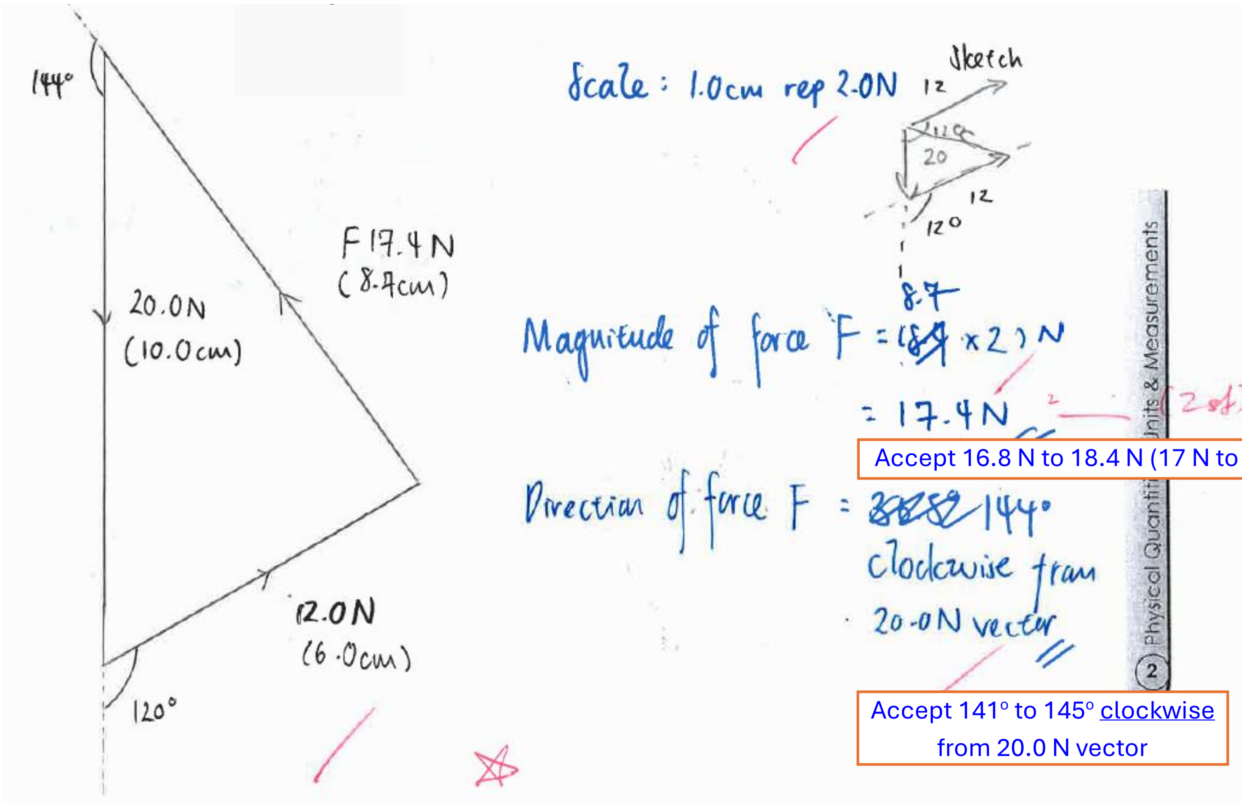
Magnitude of force $F = 8.8\text{ cm} \times 2.0\text{ N/cm}$
$= 17.6\text{ N}$

Direction of force F = 144° clockwise from the 20.0N force

Credit: Danzel Pang, 3P3

Accept 141° to 145° clockwise from 20.0 N vector

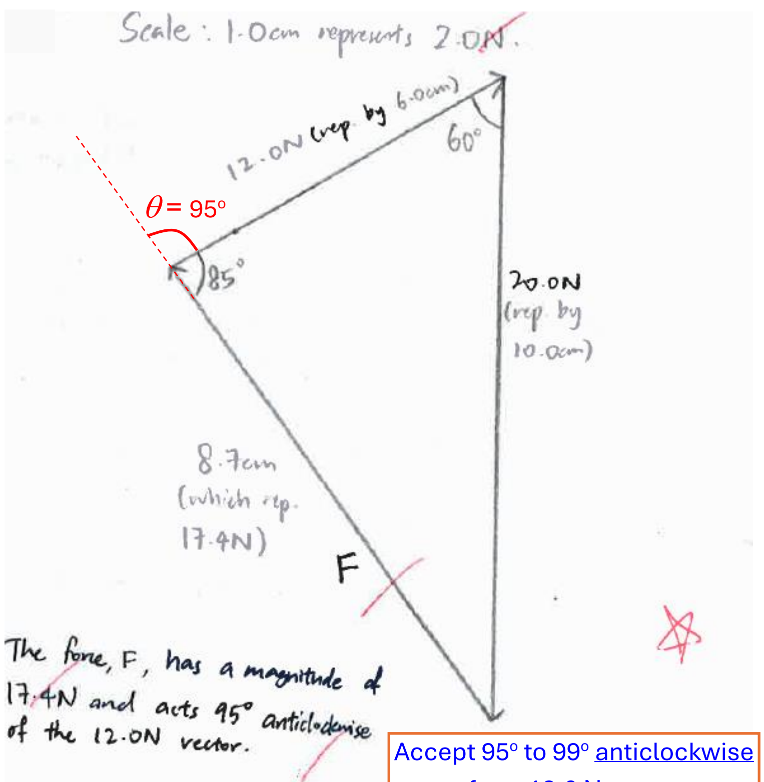
Alternative solution:



Accept 16.8 N to 18.4 N (17 N to 18 N)

Accept 141° to 145° clockwise from 20.0 N vector

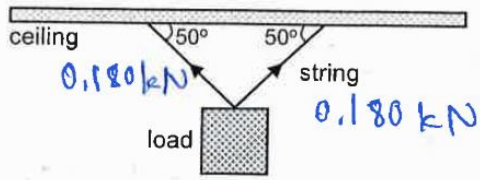
Credit: Neo Ky-Sheng, 3I2



Accept 95° to 99° anticlockwise from 12.0 N vector

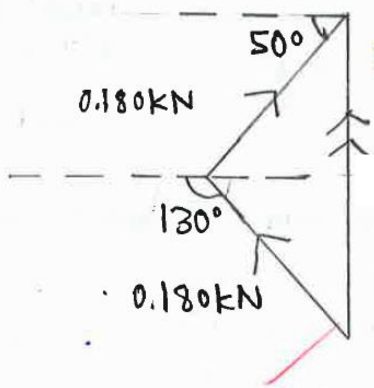
Credit: Goh Tzu Kye, 3O1

4. Two strings suspended from a ceiling are tied to a load as shown in the diagram below. Each string has a tensional force of 0.180 kN in it.



(a) By means of a suitable scale diagram, determine the resultant force R exerted by the tensional force in both strings. [4]

(b) Hence, determine the weight W of the load. [1]



scale: 1.0~~0~~ cm represents 0.060 kN

(a) magnitude of resultant R
$= 4.5\text{cm} \times 0.060\text{kN/cm}$
$= 0.27\text{kN}$ Dm?

(b) $0.27\text{kN} = 270\text{N}$
Weight = 270N Dm?

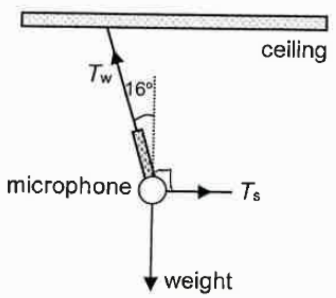
Direction:
vertically upward
OR
40° clockwise from left 0.180 kN vector

Accept 0.26 kN to 0.29 kN, acting vertically downward

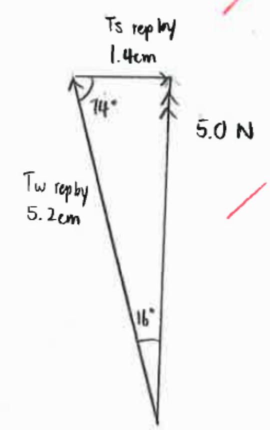
Credit: Nigel Chua, 3P3

5. A microphone of mass 5.0×10^2 g hangs from the end of a long wire fixed to the ceiling. A horizontal string attached to the microphone exerts a force that keeps it at rest with the wire at an angle of 16° to the vertical as shown in the diagram below. Using a suitable scale diagram or otherwise, determine the magnitude of the force in the string, T_s and the magnitude of the force in the wire, T_w. Assume that gravitational field strength = 10 N kg^{-1}.

[4]



1.0 cm represents 1.0 N



weight of microphone : $W = mg$

$W = 0.50 \text{ kg} \times 10 \text{ N kg}^{-1}$

$= 5.0 \text{ N}$

magnitude of T_w = 5.2cm × 1.0N/cm

= 5.2 N

Accept 5.0 N to 5.4 N

magnitude of T_s = 1.4cm × 1.0 N/cm

= 1.4 N

Accept 1.2 N to 1.6 N

Credit: Zhang Dinghao, 3O1

[4]

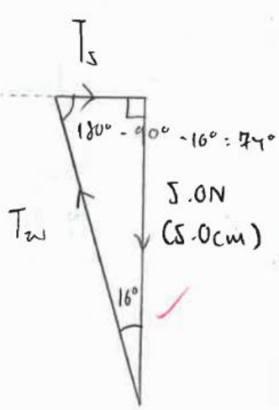
Sketch

Weight = $(5.0 \times 10^2 \div 10^3)$ kg × 10 N kg

= 5.0 N

By Sine Rule

$$\frac{5.0\text{N}}{\sin 74^\circ} = \frac{T_s}{\sin 16^\circ}$$



Magnitude of T_s

$$= \frac{5.0\text{N} \sin 16^\circ}{\sin 74^\circ}$$

= 1.4N (2 s.f.)

Magnitude of T_w

$= \sqrt{1.4^2 + 5.0^2}$ N

= 5.2 N (2 s.f.)

Credit: Neo Ky-Sheng, 3I2

6. A straight river 240 m wide flows at a rate of 1.5 m s^{-1}. A man who can row at 2.5 m s^{-1} in still water wants to cross the river in the shortest possible distance.

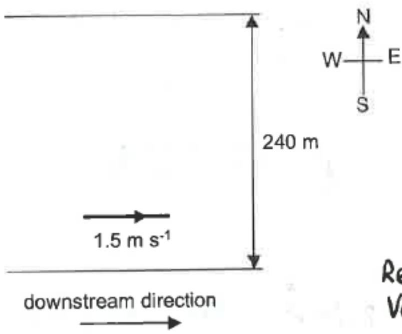
(a) Using a suitable scale diagram or otherwise, determine the direction in which he must row. [3]

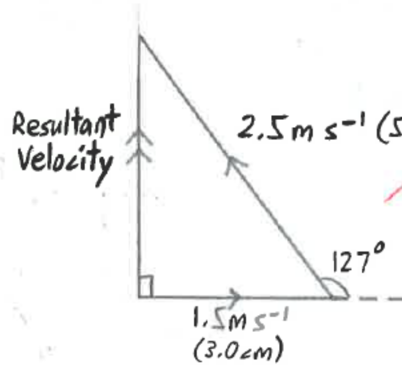
(b) How long does he take to cross the river? [2]

Hint: To cross the river in the shortest possible distance, this means the resultant velocity must act directly across the river.

(a) Scale : 1.0cm represents 0.5m s^{-1}

1.0 cm represents 0.50 m s^{-1} (so that ans are given to 2 s.f. according to qn)





Accept: 125° to 129° <u>anticlockwise</u> from 1.5 m s^{-1} vector or from downstream direction

∴ He must row 127° anticlockwise from the 1.5m s^{-1} vector

(b) Resultant velocity $= \sqrt{5.0^2 - 3.0^2} \times 0.5 \text{m s}^{-1}/\text{cm}$

$= 2.0 \text{m s}^{-1}$

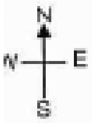
Can also get 2.0 m s^{-1} by measuring resultant velocity from scaled diagram or use $\sqrt{2.5^2 - 1.5^2}$

Time taken to cross the river $= 240\text{m} \div 2.0 \text{m s}^{-1}$

$= 120 \text{s}$

Credit: Danzel Pang, 3P3

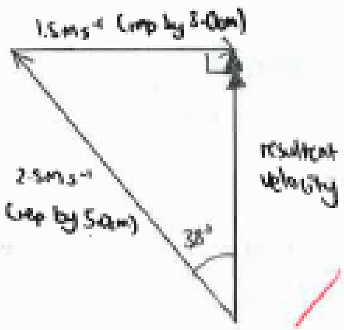
Alternative solution:



(a)

Scale: 1.0cm represents 0.5 m s^{-1}

1.0 cm represents 0.50 m s^{-1}



∴ The man must row 38° west of north

Accept 35° to 39° west of north OR 51° to 55° north of west

(b)

Magnitude of resultant velocity $= 3.9\text{cm} \times 0.5\text{ m s}^{-1}\text{ cm}^{-1}$

$\approx 2.0\text{ m s}^{-1}$ (2 s.f.)

$240\text{ m} \div 1.95\text{ m s}^{-1} \approx 123\text{ s}$ ~~(3 s.f.)~~

= ______ (2 sf)

∴ The man takes 123 s to cross the river

For scale drawing:
Accept: 1.9 m s^{-1} to 2.1 m s^{-1} for resultant velocity
Accept: 110 s to 130 s (to 2 s.f.) for time taken to cross river

Credit: Liam Poh, 3I4