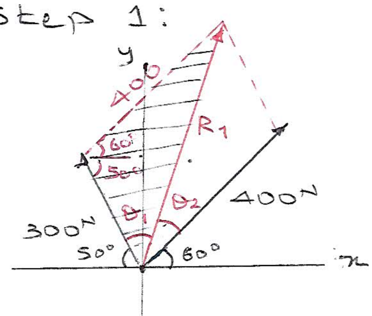
Problem Set 1 (PS1)

SOLUTION

1-

(i) Parallelogram Law:

• Step 1:



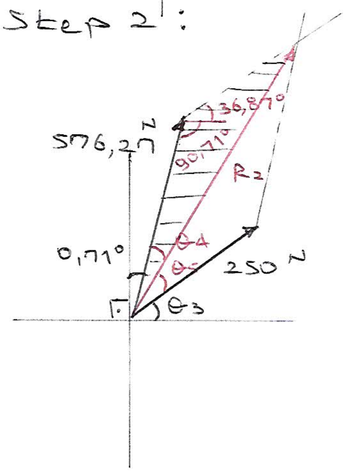
• working with shaded triangle:

$$R_1 = \sqrt{300^2 + 400^2 - 2 \cdot 300 \cdot 400 \cdot \cos(50+60)^\circ}$$
$$= 576{,}27 \text{ N}$$

$$\frac{400}{\sin\theta_1} = \frac{576{,}27}{\sin(50+60)} \Rightarrow \theta_1 = 40{,}71^\circ$$

$$50 + \theta_1 + \theta_2 + 60 = 180^\circ \Rightarrow \theta_2 = 29{,}29^\circ$$

• Step 2:



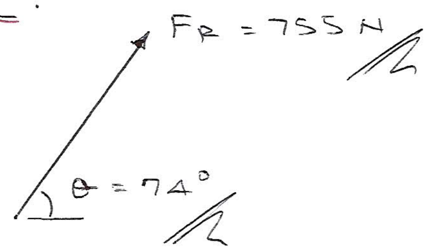
• $\tan^{-1}\theta_3 = \frac{3}{4} \Rightarrow \theta_3 = 36{,}87^\circ$

$$R_2 = \sqrt{576{,}27^2 + 250^2 - 2 \cdot 576{,}27 \cdot 250 \cdot \cos \ldots (90{,}71 + 36{,}87)^\circ}$$
$$= 755{,}18 \text{ N}$$

$$\frac{250}{\sin\theta_4} = \frac{755{,}18}{\sin(90{,}71 + 36{,}87)} \Rightarrow \theta_4 = 15{,}21^\circ$$

$$0{,}71 + \theta_4 + \theta_5 + \theta_3 = 90^\circ \Rightarrow \theta_5 = 37{,}21^\circ$$

• Answer:



(ii) Polygon Rule:

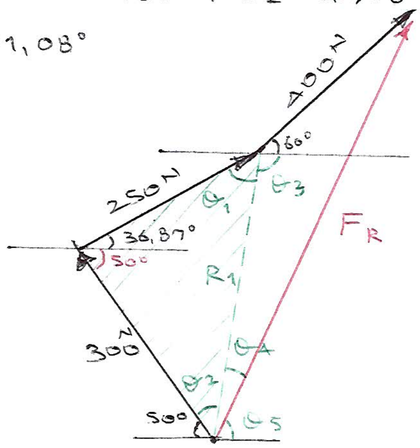
- First, work with green shaded triangle:

$R_1 = \sqrt{300^2 + 250^2 - 300 \cdot 250 \cdot 2 \cdot \cos(50+36{,}87)} = 379{,}88\ N$

$\dfrac{300}{\sin\theta_1} = \dfrac{379{,}88}{\sin(50+36{,}87)} \Rightarrow \theta_1 = 52{,}05°$

$\theta_1 + \theta_2 + 50 + 36{,}87 = 180° \Rightarrow \theta_2 = 41{,}08°$

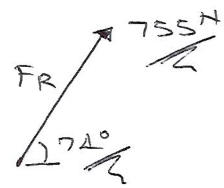
$\theta_3 = 50 + \theta_2 = 91{,}08°$



$F_R = \sqrt{379{,}88^2 + 400^2 - 2 \cdot 379{,}88 \cdot 400 \cdot \cos(91{,}08+60)} = 755{,}19\ N$

$\dfrac{400}{\sin\theta_4} = \dfrac{755{,}19}{\sin(91{,}08+60)} \Rightarrow \theta_4 = 14{,}84°$

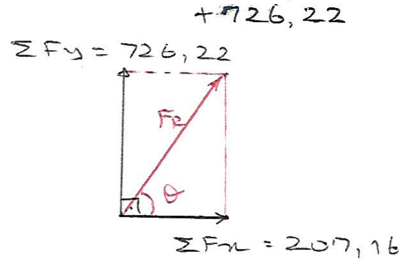
$50 + \theta_2 + \theta_4 + \theta_5 = 180° \Rightarrow \theta_5 = 74{,}08° \Rightarrow$ Answer:



(iii) Using components:

+ve

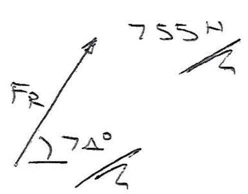
FORCE (N)	ANGLE FROM HORIZ. (°)	x-COMP. (N)	y-COMP. (N)
250	36,87	$250 \cdot \cos 36{,}87$	$250 \cdot \sin 36{,}87$
400	60	$400 \cdot \cos 60$	$400 \cdot \sin 60$
300	50	$-300 \cdot \cos 50$	$300 \cdot \sin 50$
	$\Sigma =$	$+207{,}16$	$+726{,}22$



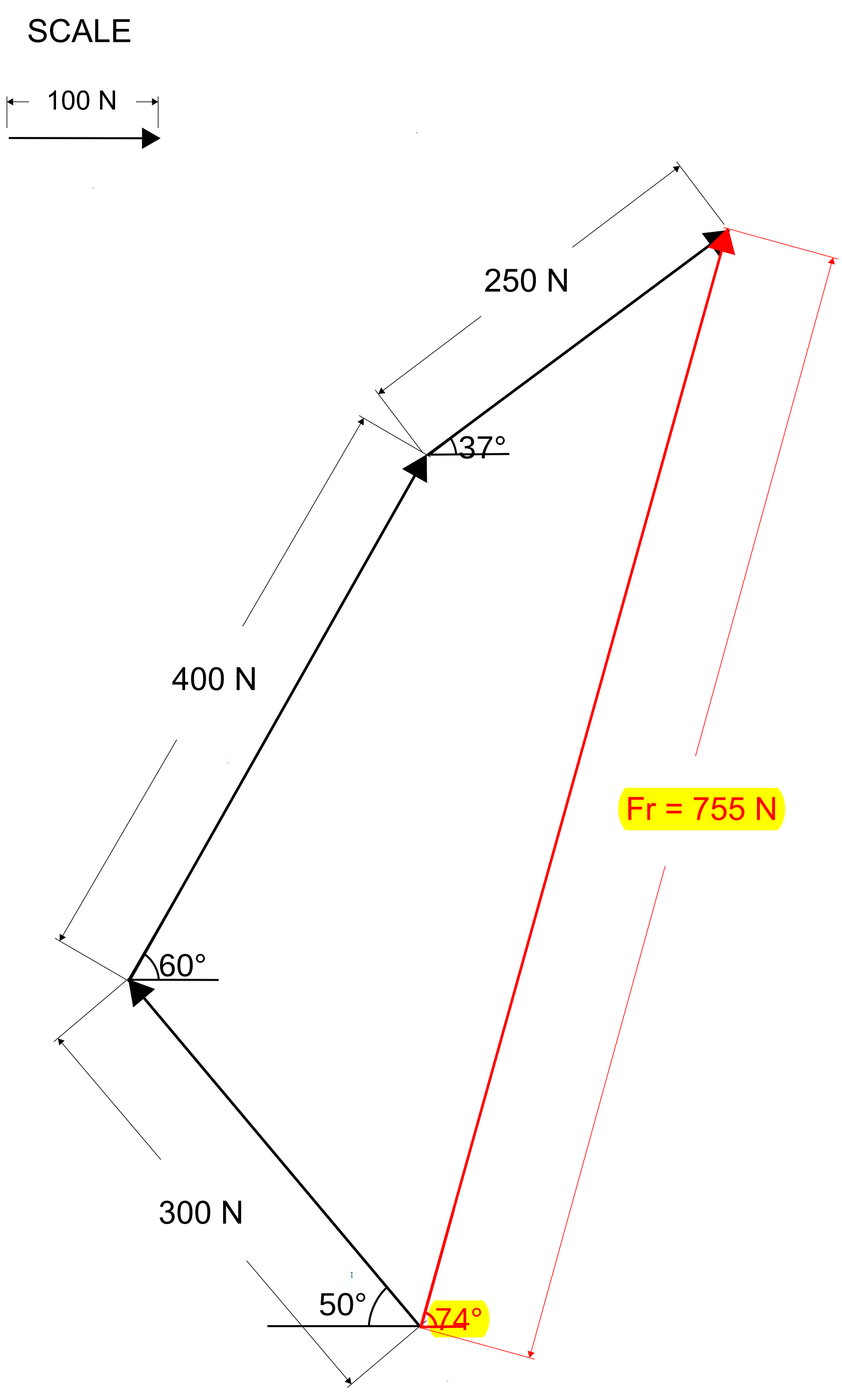
$F_R = \sqrt{207{,}16^2 + 726{,}22^2} = 755{,}19\ N$

$\tan^{-1}\theta = 726{,}22 / 207{,}16 = 74{,}08°$

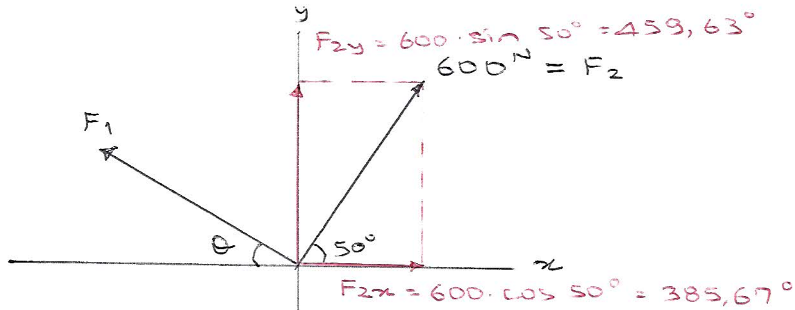
Answer:



iv- Polygon Rule, using a scaled drawing:

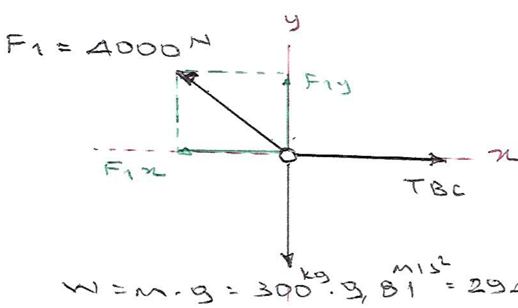


2.



- $\Sigma F_x = 0$ for resultant to be in the y axis. Therefore, $F_{1x} = F_{2x} = 385,67°$
- If $F_{1y} \neq 0$, F_1 will be larger than F_{1x}. We are required to find the min F_1.
- Consequently, $F_1 = 385,67^N$ and $\theta = 0°$ is the min F_1.
- Answer : $F_1 = 386$ N and $\theta = 0°$ (F_1 ⟵)

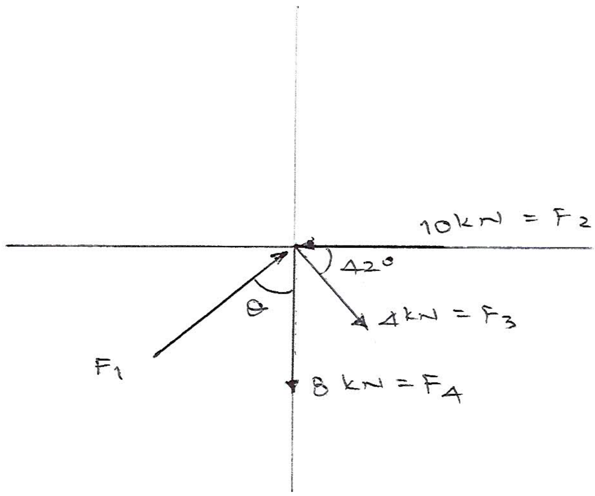
3.



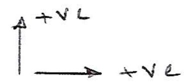
- Start directly by drawing a FBD. Select x and y axes. Select +ve directions. ↑+ ⟶+ Assume senses of unknowns. (best to assume logically.)
- As always, find components.

- Apply equations of equilibrium.
  $\Sigma F_x = 0 \Rightarrow -F_{1x} + T_{BC} = 0 \Rightarrow F_{1x} = T_{BC}$
  $\Sigma F_y = 0 \Rightarrow F_{1y} - 2943,00 = 0 \Rightarrow F_{1y} = 2943,00$ N
- F_1 and F_{1y} is known. Find F_{1x}
  $F_{1x} = \sqrt{F_1^2 - F_{1y}^2} = 2709,01$ N $\Rightarrow T_{BC} = 2709,01$ N
- Find distance y : $\frac{4000,00}{1,6^m} = \frac{2943,00^N}{y} \Rightarrow y = 1,18$ m
- Answer : $T_{BC} = 2,71$ kN and $y = 1,2^m$

4-



- Use tabulated solut.
- Select +ve directions



Force	Angle from horiz.	x-comp.	y-comp.
F_1	$90-\theta$	$+F_1 \cdot \cos(90-\theta)$	$+F_1 \cdot \sin(90-\theta)$
F_2	0	-10	0
F_3	42	$+4 \cdot \cos 42°$	$-4 \cdot \sin 42°$
F_4	90	0	-8
		+	+

- Apply eq's of equil. $\Sigma F_x = 0$ (1) $\qquad \Sigma F_y = 0$ (2)

(1) : $F_1 \cdot \cos(\overbrace{90-\theta}^{\alpha}) - 10 + 4 \cdot \cos 42 = 0 \Rightarrow F_1 \cdot \cos\alpha = 7{,}03$ kN

(2) : $F_1 \cdot \sin(90-\theta) - 4 \cdot \sin 42 - 8 = 0 \Rightarrow F_1 \cdot \sin\alpha = 10{,}68$ kN

- Solve (1) and (2) to get : $\alpha = 56{,}65° \Rightarrow \theta = 33{,}35°$

$\Rightarrow F_1 = 12{,}79$ kN

- Answer : $F_1 = 13$ kN and $\theta = 33°$

END OF SOLUTION.