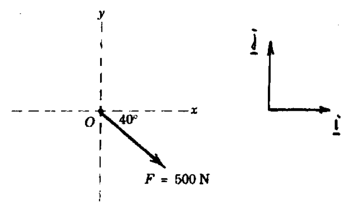
TAM 202 HW1 Solution provided by Tian Tang.

2/1, 2/11, 2/24, due 01/21/03.

2/1

2/1 The force **F** has a magnitude of 500 N. Express **F** as a vector in terms of the unit vectors **i** and **j**. Identify the x and y scalar components of **F**.
Ans. $\mathbf{F} = 383\mathbf{i} - 321\mathbf{j}$ N, $F_x = 383$ N, $F_y = -321$ N



Problem 2/1

$$\underline{F} = F_x\,\underline{i} + F_y\,\underline{j}$$

$$= F(\cos 40^\circ\,\underline{i} - \sin 40^\circ\,\underline{j})$$

$$= (500\,N)(\cos 40^\circ\,\underline{i} - \sin 40^\circ\,\underline{j})$$

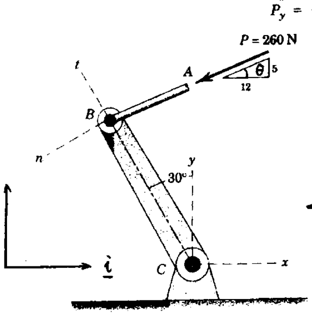
$$= (383\,N)\,\underline{i} + (-321\,N)\,\underline{j}$$

$$\Rightarrow \quad F_x = 383\,N$$

$$F_y = -321\,N$$

2/11

2/11 In the design of a control mechanism, it is determined that rod AB transmits a 260-N force **P** to the crank BC. Determine the x and y scalar components of **P**.
Ans. $P_x = -240$ N
$P_y = -100$ N

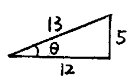


Problem 2/11

$\tan\theta = \frac{5}{12}$

$\sin\theta = \frac{5}{13}$

$\cos\theta = \frac{12}{13}$



$$\underline{P} = P_x\,\underline{i} + P_y\,\underline{j}$$

$$= P(-\cos\theta\,\underline{i} - \sin\theta\,\underline{j})$$

(Continued)

$$= (260\,N)(-\tfrac{12}{13}\,\underline{i} - \tfrac{5}{13}\,\underline{j})$$

$$= (-240\,N)\,\underline{i} + (-100\,N)\,\underline{j}$$

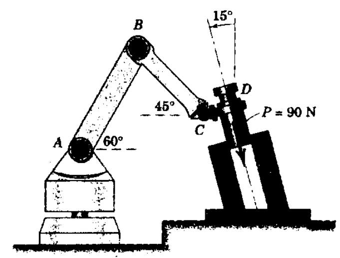
$$\Rightarrow \quad P_x = -240\,N$$

$$P_y = -100\,N$$

2/24

2/24 In the design of the robot to insert the small cylindrical part into a close-fitting circular hole, the robot arm must exert a 90-N force P on the part parallel to the axis of the hole as shown. Determine the components of the force which the part exerts *on* the robot along axes (a) parallel and perpendicular to the arm AB, and (b) parallel and perpendicular to the arm BC.

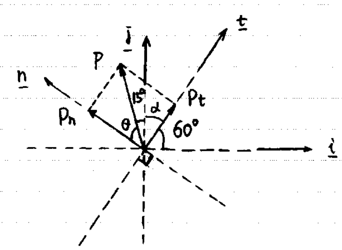
← Note: By action and reaction, they are asking for negative of the force shown.



Problem 2/24

Method 1

(a)



* Define this reaction vector as $\underline{P}$.

$$\theta = 90^\circ - 15^\circ - \alpha$$

$$= 90^\circ - 15^\circ - (90^\circ - 60^\circ) = 45^\circ$$

$$\Rightarrow \quad \underline{P} = P_t\,\underline{t} + P_n\,\underline{n}$$

$$= P(\sin\theta\,\underline{t} + \cos\theta\,\underline{n})$$

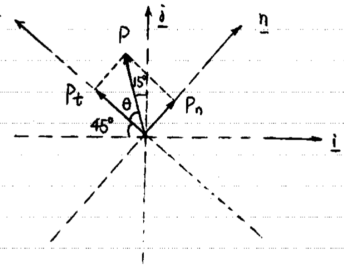
$$= (90\,N)(\sin 45^\circ\,\underline{t} + \cos 45^\circ\,\underline{n})$$

$$= (63.6\,N)\,\underline{t} + (63.6\,N)\,\underline{t}$$

$$\Rightarrow \quad P_t = 63.6\,N \qquad P_n = 63.6\,N$$

(Continued)

(b)



$\theta = 90° - 45° - 15° = 30°$

$\Rightarrow \underline{P} = P_t \underline{t} + P_n \underline{n}$

$= P(\cos\theta\, \underline{t} + \sin\theta\, \underline{n})$

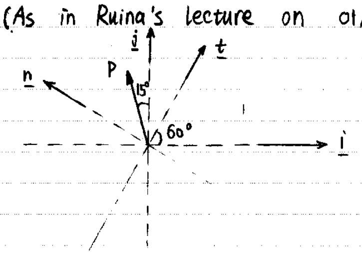
$= (90\,N)(\cos 30°\, \underline{t} + \sin 30°\, \underline{n})$

$= (77.9\,N)\underline{t} + (45\,N)\underline{n}$

$\Rightarrow P_t = 77.9\,N \qquad P_n = 45\,N$

Method 2 (As in Ruina's lecture on 01/22/03)

(a)



$\underline{P} = P(-\sin 15°\, \underline{i} + \cos 15°\, \underline{j})$

$\underline{t} = \cos 60°\, \underline{i} + \sin 60°\, \underline{j}$

$\underline{n} = -\sin 60°\, \underline{i} + \cos 60°\, \underline{j}$

$P_t = \underline{P} \cdot \underline{t} = P(-\sin 15°\, \underline{i} + \cos 15°\, \underline{j}) \cdot (\cos 60°\, \underline{i} + \sin 60°\, \underline{j})$

$= P[-\sin 15° \cos 60° + \cos 15° \sin 60°]$

$= P \sin(60° - 15°)$

$= P \sin 45°$

$= (90\,N) \sin 45°$

$= 63.6\,N$

(Continued)

$P_n = \underline{P} \cdot \underline{n} = P(-\sin 15°\, \underline{i} + \cos 15°\, \underline{j}) \cdot (-\sin 60°\, \underline{i} + \cos 60°\, \underline{j})$

$= P[\sin 15° \sin 60° + \cos 15° \cos 60°]$

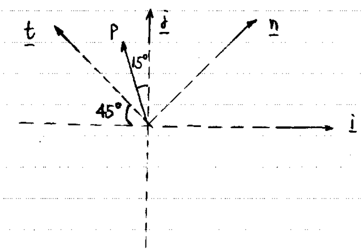
$= P \cos(60° - 15°)$

$= P \cos 45°$

$= (90\,N) \cos 45°$

$= 63.6\,N$

(b)



$\underline{P} = P(-\sin 15°\, \underline{i} + \cos 15°\, \underline{j})$

$\underline{t} = -\cos 45°\, \underline{i} + \sin 45°\, \underline{j}$

$\underline{n} = \sin 45°\, \underline{i} + \cos 45°\, \underline{j}$

$\Rightarrow P_t = \underline{P} \cdot \underline{t} = P(-\sin 15°\, \underline{i} + \cos 15°\, \underline{j}) \cdot (-\cos 45°\, \underline{i} + \sin 45°\, \underline{j})$

$= P(\sin 15° \cos 45° + \cos 15° \sin 45°)$

$= P \sin(15° + 45°)$

$= (90\,N) \sin 60°$

$= 77.9\,N$

$P_n = \underline{P} \cdot \underline{n} = P(-\sin 15°\, \underline{i} + \cos 15°\, \underline{j}) \cdot (\sin 45°\, \underline{i} + \cos 45°\, \underline{j})$

$= P(-\sin 15° \sin 45° + \cos 15° \cos 45°)$

$= P \cos(15° + 45°)$

$= (90\,N) \cos 60°$

$= 45\,N$