PROBLEM 1.6 | THE FIGURE SHOWS A SECTIONAL VIEW OF A CLUTCH. THE PRESSURE ON THE CLUTCH PLATE $p = 180$ kPa IS DISTRIBUTED OVER AN ANNULAR AREA OF INSIDE RADIUS OF 75mm AND OUTER RADIUS OF 150mm. USING APPROPRIATE FREE-BODY DIAGRAMS AND EQUILIBRIUM EQUATIONS, DETERMINE THE FORCE "F" REQUIRED TO MAINTAIN THE POSITION SHOWN.

GIVEN:

CONSTRAINTS

1. 180 kPa PRESSURE APPLIED TO THE CLUTCH.
2. FORCE APPLIED TO A CONE ON A SHAFT ~~MAINTAINS~~ MAINTAINS THE POSITION OF THE CLUTCH.

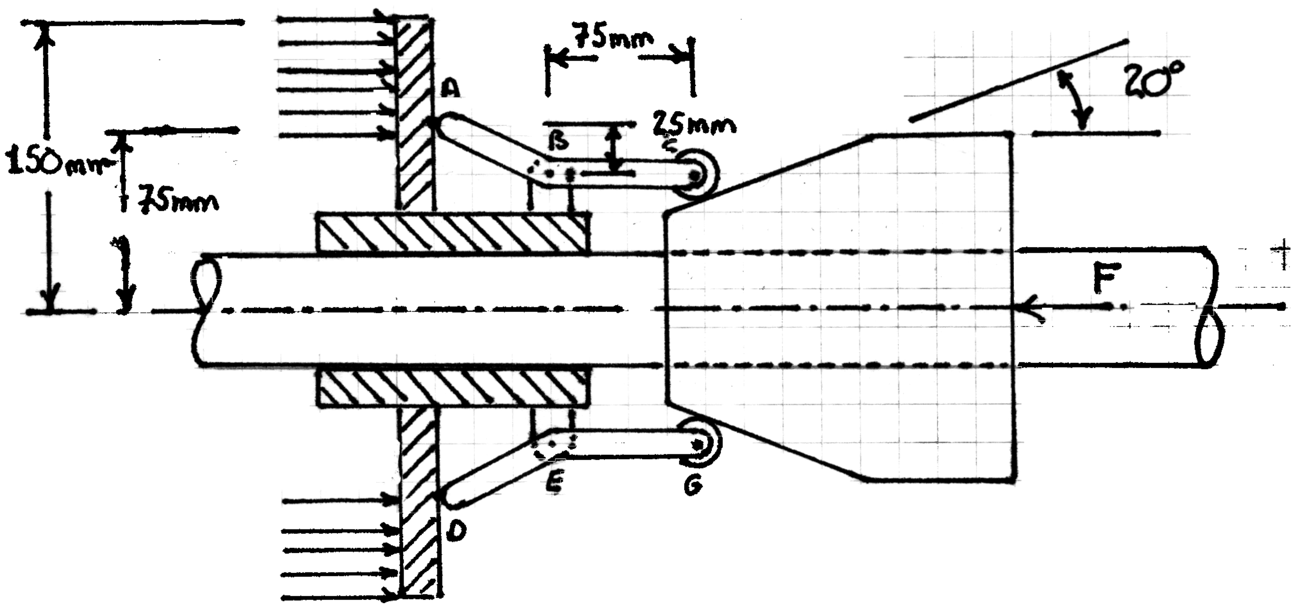
ASSUMPTIONS

1. CONE SLIDES WITHOUT FRICTION ON SHAFT
2. LEVER ARM ROTATES WITHOUT FRICTION AS DOES THE ROLLER

FIND:

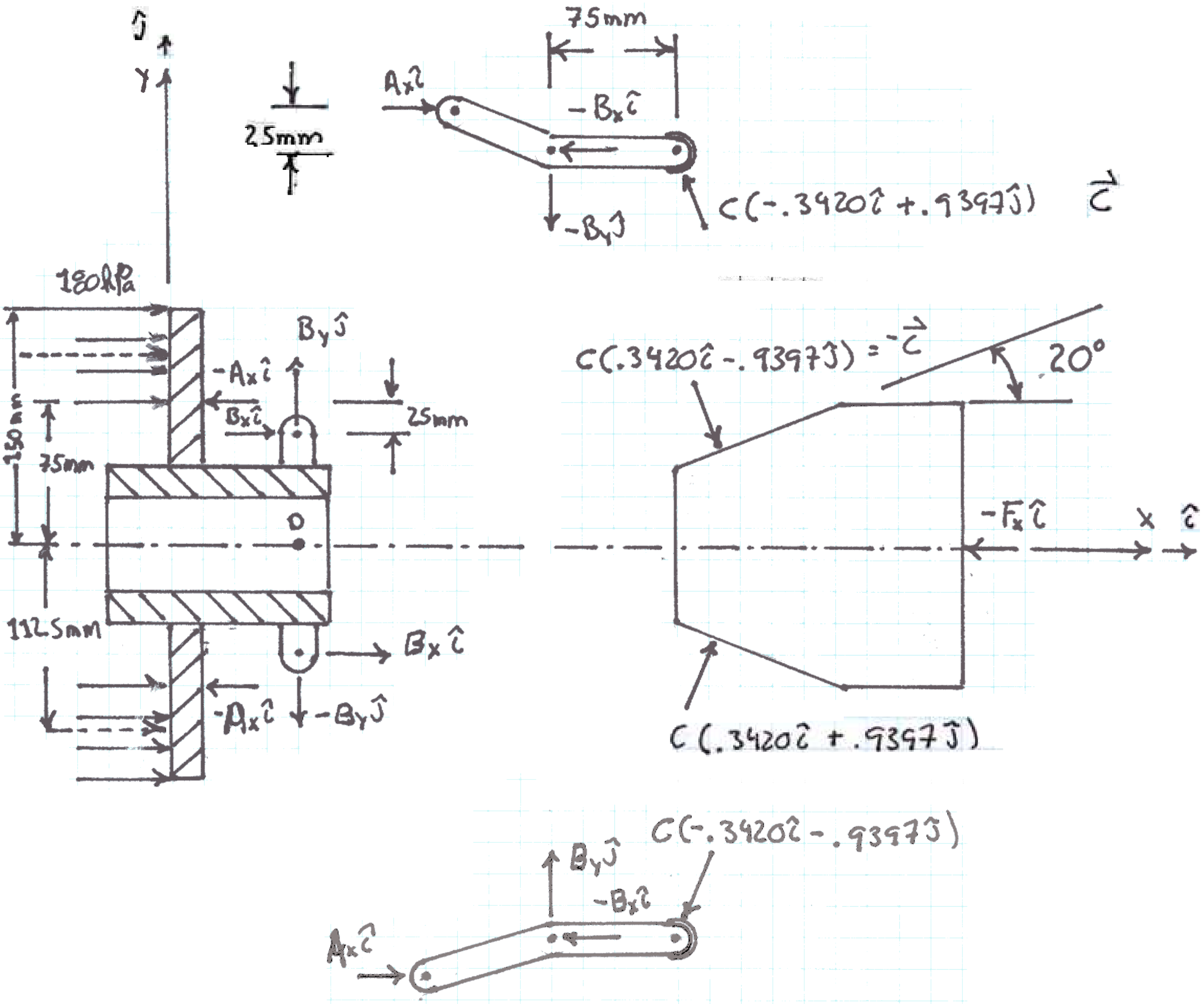
1. DETERMINE THE FORCE "F" REQUIRED TO MAINTAIN EQUILIBRIUM

DIAGRAM:



(A)

FREE BODY DIAGRAM:



SOLUTION:

THIS PROBLEM CONTAINS A LOT OF SYMMETRY. AS A RESULT ALL THE CORRESPONDING FORCES ABOVE AND BELOW THE CENTER LINE ARE EQUAL.

STARTING WITH THE DISK. THE AREA THAT THE 180 kPa PRESSURE ACTS OVER IS

$$A_{DISK} = \pi(r_o^2 - r_i^2) = \pi[(.150\,m)^2 - (.075\,m)^2] = 0.05301\,m^2 \quad ①$$

THE TOTAL FORCE BEING APPLIED TO THE DISK AS A RESULT OF THE PRESSURE LOADING

$$F_{DISK} = 180(10^3)\frac{N}{m^2} \cdot 0.05301\,m^2 = 9.543(10^3)N \quad ②$$

THIS FORCE IS UNIFORMLY DISTRIBUTED AROUND THE DISK AT A DISTANCE OF 112.5mm. USING THE FREE BODY DIAGRAM OF THE DISK IN (B)

$$\Sigma F_x = 0 = 2 \cdot B_x - 2 \cdot A_x + 9.543(10^3)N$$

$$\Rightarrow 2 \cdot A_x - 2 \cdot B_x = 9.543(10^3)N \Rightarrow A_x - B_x = 4.772(10^3)N \quad ③$$

$$\Sigma F_y = 0 = B_y - B_y \quad \checkmark$$

NOW LETS CONSIDER THE ROCKER-ARM "ABC".

$$\Sigma F_x = A_x - B_x - .3420 \cdot C = 0$$

$$\Rightarrow A_x - B_x = .3420 \cdot C \quad ④$$

COMPARING ③ AND ④ WE CAN WRITE

$$\underbrace{A_x - B_x = 4.772(10^3)N}_{③} = \underbrace{.3420 \cdot C = A_x - B_x}_{④}$$

$$\Rightarrow .3420 \cdot C = 4.772(10^3)N \Rightarrow C = \frac{4.772(10^3)N}{.3420} = \underline{\underline{13.95(10^3)N}} \quad ⑤$$

$$\Rightarrow \vec{C} = 13.95(10^3)N(-.3420\,\hat{i} + .9397\,\hat{j})$$

$$= -4.771(10^3)N\,\hat{i} + 13.12(10^3)N \quad ⑥$$

CONTINUING WITH EQUILIBRIUM OF THE ROCKER-ARM "ABC"

$$\Sigma F_y = 0 = -B_y + .9397 \cdot C = -B_y + 13.12(10^3)\,N$$

$$\Rightarrow \underline{\underline{B_y = 13.12(10^3)\,N}}$$

$$\Sigma M_{z/@B} = 0 = -(0.025m) \cdot A_x + (0.075m) \cdot (13.12(10^3)\,N)$$

$$\Rightarrow A_x = \frac{(0.075m) \cdot (13.12(10^3)\,N)}{0.025m} = \underline{\underline{39.36(10^3)\,N}}$$

FROM 3

$$39.36(10^3)\,N - B_x = 4.772(10^3)\,N$$

$$\Rightarrow \underline{\underline{B_x = 34.59(10^3)\,N}}$$

NOW THE EQUILIBRIUM OF THE CONE CAN BE CONSIDERED

$$\Sigma F_x = 0 = -F_x + 2 \cdot .3420 \cdot C = -F + 2 \cdot (4.772(10^3)\,N)$$

$$\Rightarrow F = 2 \cdot (4.772(10^3)\,N) = \boxed{9.544(10^3)\,N}$$

<u>SUMMARY</u>:

THIS IS ACTUALLY AN AXIS-SYMMETRIC PROBLEM THAT IS SIMPLIFIED BY USING EQUIVALENT FORCES. CARE MUST BE TAKEN TO ACCOUNT FOR THE LOADING ABOVE AND BELOW THE AXIS OF SYMMETRY AS SHOWN IN FIGURE B