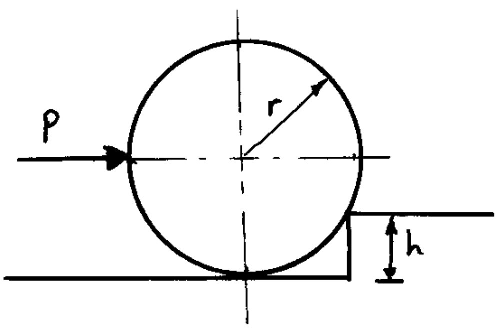
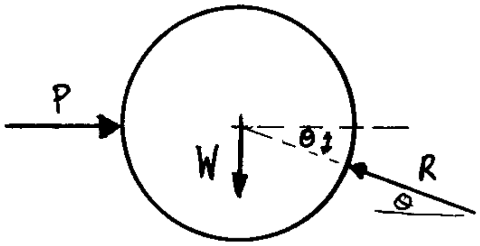
3/21 find P such that cylinder will begin to roll over the step.



FREE BODY DIAGRAM



R is exerted at point of CONTACT AND IS NORMAL TO SURFACE (we are assuming contact is smooth)

Note, no force @ bottom SURFACE because we assume CYLINDER is ABOUT to roll over obstacle, i.e. beginning to LIFT.

EQUILIB CONDITIONS

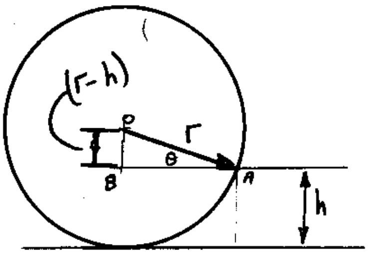
$$\sum F_x = 0$$

$$P - R\cos\theta = 0$$

if we look at geometry

OR

$$P - R\left(\frac{\sqrt{2rh-h^2}}{r}\right) = 0 \quad (1)$$



$\|OB\| = r-h$

$\|OA\| = r$

$$\|BA\| = \sqrt{r^2-(r-h)^2} = \sqrt{r^2-r^2+2rh-h^2} = \sqrt{2rh-h^2}$$

$$\Rightarrow \cos\theta = \frac{\sqrt{2rh-h^2}}{r} \qquad \sin\theta = \frac{r-h}{r}$$

$$\sum F_y = 0 \Rightarrow W - R\sin\theta = 0$$ or equivalently

$$W - R\left(\frac{r-h}{r}\right) = 0 \quad (2)$$

Eliminate R between (1) & (2)

$$W - \left(\frac{r-h}{r}\right)P\left(\frac{r}{\sqrt{2rh-h^2}}\right) = 0$$ note $W = mg$ so

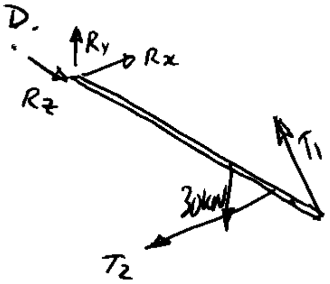
$$mg = P\frac{r-h}{\sqrt{2rh-h^2}} \quad \text{and} \quad \underline{\underline{P = \frac{mg\sqrt{2rh-h^2}}{r-h}}}$$

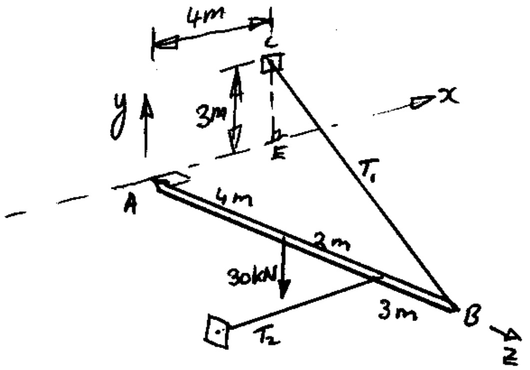
note $r > h$, as $r \to h$ $P \to \infty$ ... v. hard to push.

if $r < h \Rightarrow$ SQUARE ROOT $\to$ IMAGINARY; i.e. impossible

$\boxed{3/109}$

F.B.D.





TAKE MOMENT ABOUT x axis

$$(30\,kN)(4) - (T_{1y})(9) = 0 \Rightarrow T_{1y} = 13.33\,kN$$

$\vec{T_1}$ is directed along cord CB $\Rightarrow$ components must correspond to components of $\vec{BC}$

i.e. $T_{1x} = \left(\frac{T_{1y}}{3}\right)(4) = \left(\frac{13.33}{3}\right)(4) = 17.77\,kN$

$T_{1z} = -\left(\frac{T_{1y}}{3}\right)(9) = -\left(\frac{13.33}{3}\right)(9) = -39.99\,kN$

$\therefore \vec{T_1} = 17.77\hat{i} + 13.33\hat{j} - 39.99\hat{k}$ kN

& $\underline{\underline{\|\vec{T_1}\| = 45.75\,kN}}$

TAKE moments ABOUT y axis and apply EQUILIB CONDITION

$$(T_{1x})(9) - (T_2)(6) = 0 \Rightarrow T_2 = \frac{(T_{1x})(9)}{6} = \frac{(17.77)(9)}{6}$$

$\underline{\underline{\|\vec{T_2}\| = 26.655\,kN}}$ & $\vec{T_2} = -26.655\hat{i}$ (kN).

Finally use two force EQUILIB equations to get R_x & R_y & R_z at A

$\sum F_z = 0 \quad R_z\hat{k} - 39.99\hat{k} = \vec{0} \Rightarrow R_z = 39.99$ kN

$\sum F_x = 0 \quad R_x\hat{i} + 17.77\hat{i} - 26.655\hat{i} = \vec{0} \Rightarrow R_x = 8.89\,kN$

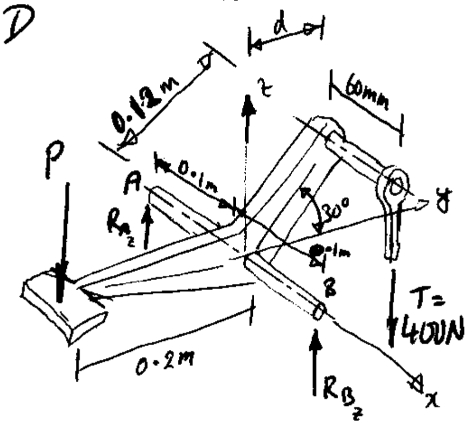
$\sum F_y = 0 \quad R_y\hat{j} - 30\hat{j} + 13.33\hat{j} = \vec{0} \Rightarrow R_y = 16.67\,kN$

$\|\vec{R}\| = \sqrt{39.99^2 + 8.89^2 + 16.67^2} = \underline{\underline{44.23\,kN}}$

3/101

note P & T are vertical ⇒ rxn forces are vertical too

F.B.D



distance $d = (120)\cos(30°) = 60\sqrt{3}$

take moments about x axis and apply Equilib $\Sigma M = 0$
(Note that A-B is a BEARING).

$$(P)(0.2) - (400)(0.12)(\cos 30°) = 0$$

$$\Rightarrow P = 207.85\,kN \quad \text{(DOWN, as SHOWN)}.$$

$$R_{A_z} + R_{B_z} - P - T = 0$$

$$\Rightarrow R_{A_z} + R_{B_z} = 400 + 207.85 = 607.85$$

Take moments about y-axis and apply Equilib

$$+(T)(0.06) - (R_{B_z})(0.1) + (R_{A_z})(0.1) = 0$$

$$R_{A_z} - R_{B_z} = \frac{-(400)(0.06)}{0.1} = -240$$

We have two equations

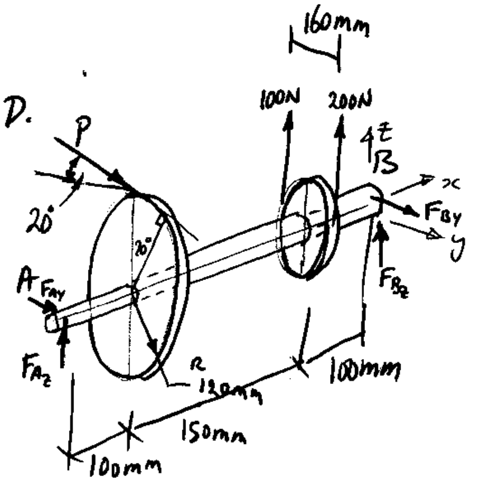
$$R_{A_z} - R_{B_z} = -240$$
$$R_{A_z} + R_{B_z} = 607.85$$

$$\Rightarrow R_{A_z} = \left(\frac{607.85 - 240}{2}\right) = \underline{\underline{183.925\,N}}$$

$$R_{B_z} = (607.85 - 183.925) = \underline{\underline{423.925\,N}}$$

3/115

F.B.D.



find gear tooth force P and Reactions supported at A and B

To find P, take moments about shaft and apply equilibrium assuming no friction in shaft bearings

$$-(200)(80) + (100)(80) + (P)(120)(\cos 20°) = 0 \qquad \text{Nmm}$$

$$\Rightarrow P = \frac{(80)(100)}{(120)(\cos 20°)} = \underline{\underline{70.945\ N}}$$

$$\Sigma F_y = 0 \qquad F_{By} + F_{Ay} + P\cos(20°) = 0 \qquad ①$$

$$\Sigma F_z = 0 \qquad F_{Bz} + F_{Az} - P\sin(20°) + 300N = 0 \qquad ②$$

Take moments about a vertical axis thru A

$$-P\cos(20°)(100) - F_{By}(350) = 0 \qquad F_{By} = -\frac{(70.945)(\cos 20°)(100)}{(350)} = -19.05N$$

Take moments about a horizontal axis thru A

$$-P(\sin 20°)(100) + (300)(250) + (F_{Bz})(350) = 0$$

$$F_{Bz} = \frac{(70.945)(\sin 20°)(100) - (300)(250)}{(350)} = -207.35\ N$$

$$\therefore \|F_B\| = \sqrt{207.35^2 + 19.05^2} = \underline{\underline{208.2\ N}}$$

Return to ① & ②

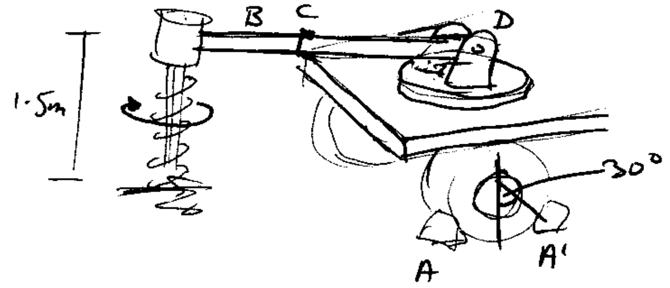
$$F_{Ay} = -P(\cos 20°) - F_{By} = -47.6N$$

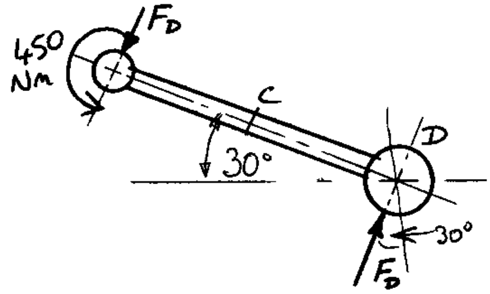
$$F_{Az} = P(\sin 20°) - 300 - F_{Bz} = -68.4N$$

$$\|F_A\| = \sqrt{47.6^2 + 68.4^2} = \underline{\underline{83.3N}}$$

$\boxed{3/103}$ first, assume rotation shown in figure is the direction of torque applied to the auger. the torque exerted on the motor will be equal and opposite.

take the offered hint and look on problem from above, DRAW F.B.D for arm





NOTE; free rotation at D
$\Rightarrow$ no moment applied there
free slide at C
$\Rightarrow$ no force parallel to arm

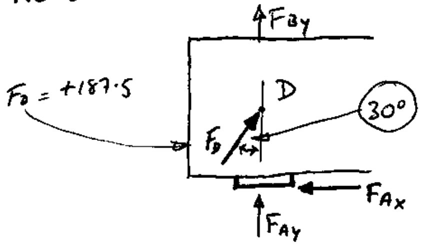
Apply Equilib

$\Rightarrow \sum M_D = 0 \qquad (F_D)(2.4) + M = 0$

$$\Rightarrow F_D = \frac{-M}{2.4} = \frac{-450}{2.4} = -187.5$$

minus sign $\Rightarrow$ F in opposite dirtn to that shown.

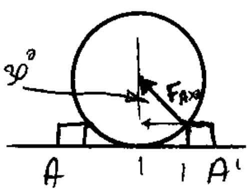
NOW TRACK



ONLY need x dirn

$\Rightarrow F_{Ax} = F_D \sin(30°) = (187.5)(\sin 30°)$

NOW Look at wheel



if Hz component is $(187.5)(\sin 30°)$

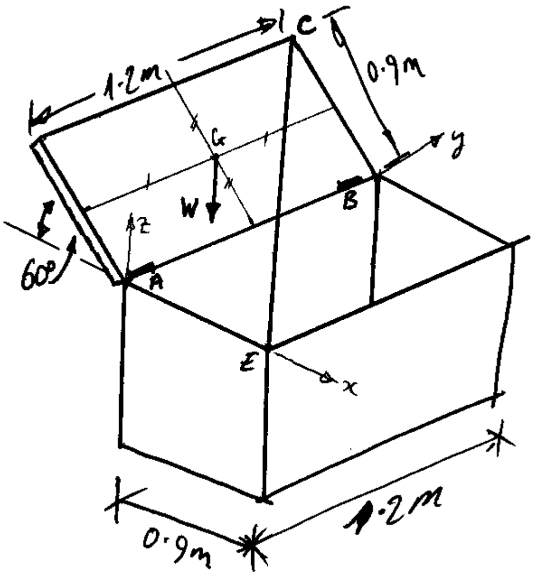
$\Rightarrow$ Radial component is

$\underline{\underline{187.5\ N}}$

$\underline{\underline{\text{at } A'}}$

3/119 Hinge B supports thrust in dirxn AB
· A does not
mass = 45kg

find Tension in wire CE



N.B. WE ARE ONLY ASKED FOR ~~MOMENT ABOUT~~ TENSION in CE. THIS MAKES PROBLEM A LOT SIMPLER...

call tension $\vec{T}$. Dirxn is parallel to $\vec{CE}$

find UNIT VECTOR IN THIS DIRXN

$$\vec{t} = \frac{\vec{CE}}{\|\vec{CE}\|} = \frac{(0.9 + 0.9\cos 60°)\hat{\imath} - 1.2\hat{\jmath} - (0.9\sin 60°)\hat{k}}{\|\vec{CE}\|}$$

Top line: $1.35\hat{\imath} - 1.2\hat{\jmath} - 0.779\hat{k}$

Bottom line: $\sqrt{1.35^2 + 1.2^2 + 0.779^2} = 1.687$

$\therefore \vec{t} = 0.686\hat{\imath} - 0.610\hat{\jmath} - 0.396\hat{k}$ and $\vec{T} = \|\vec{T}\|\vec{t}$

now, take moments about the axis AB, then apply equilibrium

forces at A and B have no moment as they pass thru this axis

weight has moment $-W(0.45)(\cos 60°)$ Note sign - Right hand rule.

$\vec{T}$ has moment also.

Consider $\vec{T}$ @ point E (you could use any point along line of action, but some are handier than others).

x component has no moment ... passes thru AB axis
y " " " " parallel to AB Axis
z component HAS A MOMENT given by

$$\|\vec{T}\|(0.396)(0.9)$$

Equilib

$$\Sigma M = 0$$

$$\Rightarrow \|\vec{T}\|(0.396)(0.9) + W(0.45)(\cos 60°) = 0$$

$$\Rightarrow \|\vec{T}\| = \frac{(45)(9.81)(0.45)(0.5)}{(0.396)(0.9)} = \underline{\underline{278.69\,N}}$$

Note we did not find forces in hinges A & B. We did not need to to do so is a longer undertaking.