Statics - TAM 211

Lecture 35

April 16, 2018

Chap 5.5-5.6

Announcements

- Upcoming deadlines:
  - Monday (4/16)
    - Mastering Engineering Tutorial 14
  - Tuesday (4/17)
    - PL HW 13
  - Monday (4/23)
    - Mastering Engineering Tutorial 15
  - Quiz 6
    - CBTF (4/25-27)
  - Written Assignment 6
    - Wednesday May 2 ← Note day!

Chapter 5 Part II – 3-D Rigid Body

Chap 5.5-5.6

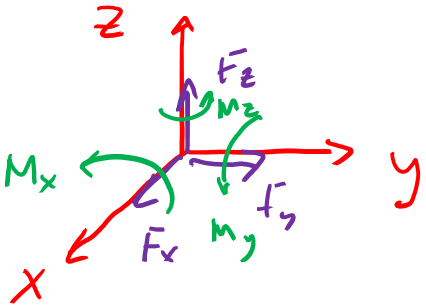
Equilibrium of a rigid body

Now we add the z-axis to the coordinate system!

Equilibrium of a rigid body

Now we add the z-axis to the coordinate system!

How many Equations of Equilibriums?



Six equations!

2D Problems

Translation: $\sum F_x = 0, \sum F_y = 0, \sum F_z = 0$

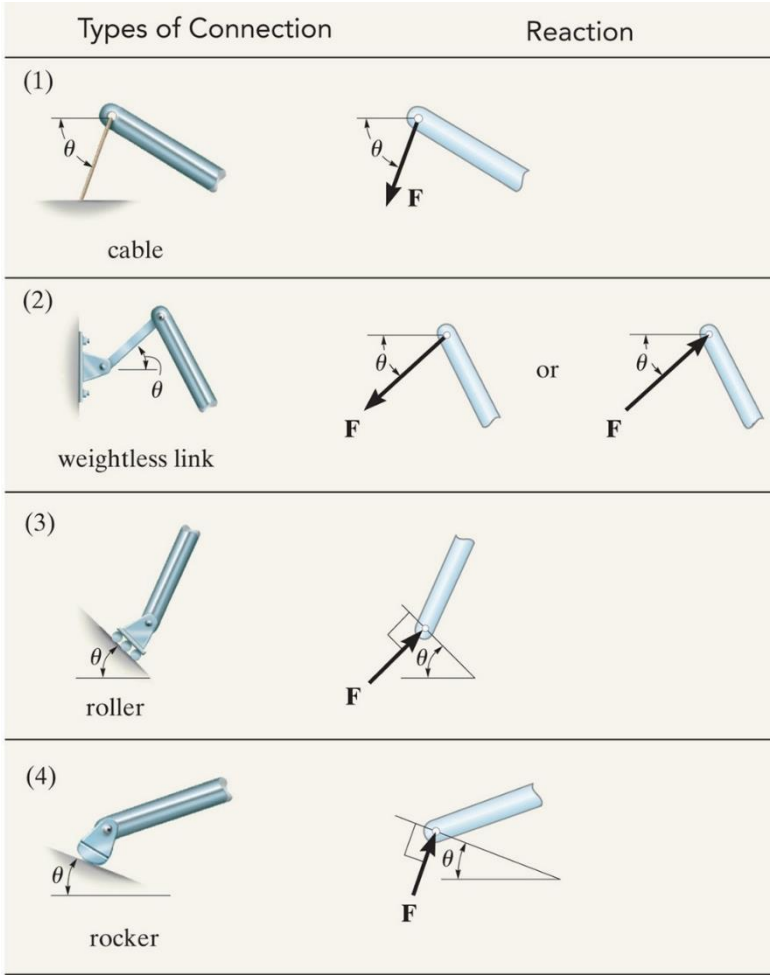
Rotation: $\sum M_x = 0 \quad \sum M_y = 0 \quad \sum M_z = 0$

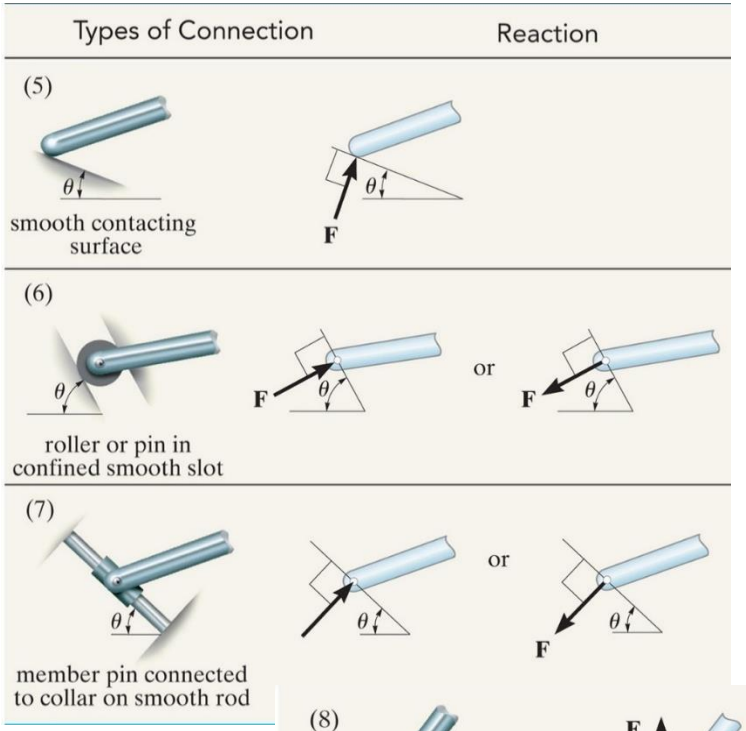
6 Eqns

⇒ 6 unknowns can be solved!

For one FBD

Types of 2D connectors





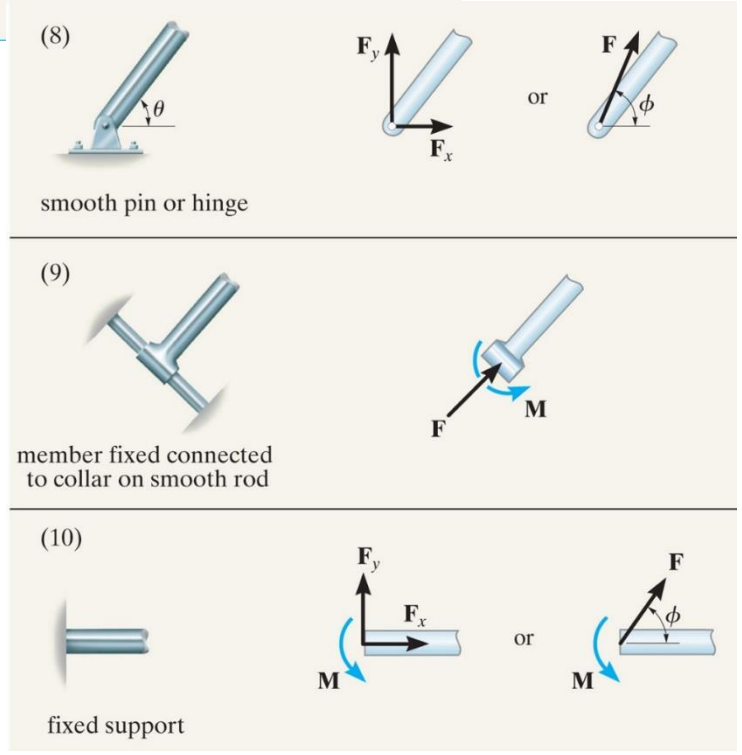


TABLE 5–2 Supports for Rigid Bodies Subjected to Three-Dimensional Force Systems

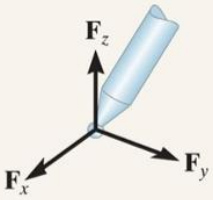
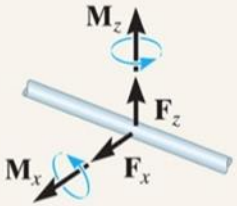
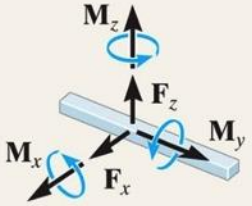
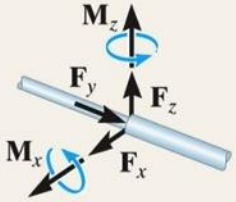
Types of Connection	Reaction	Number of Unknowns
(1)  cable		
(2)  smooth surface support		
(3)  roller		
(4)  ball and socket		

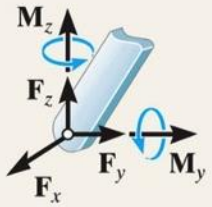
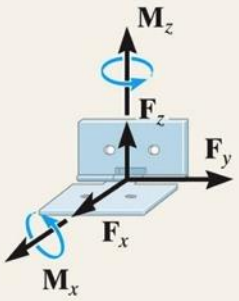
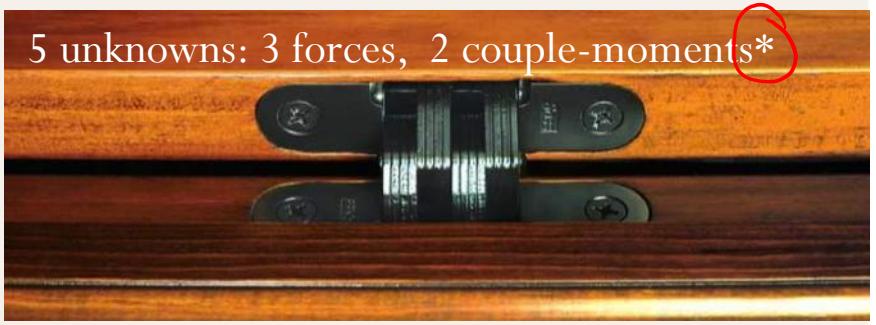
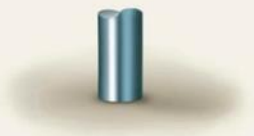
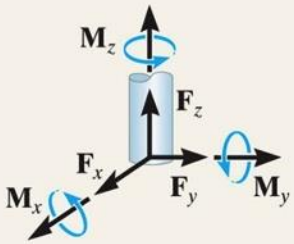
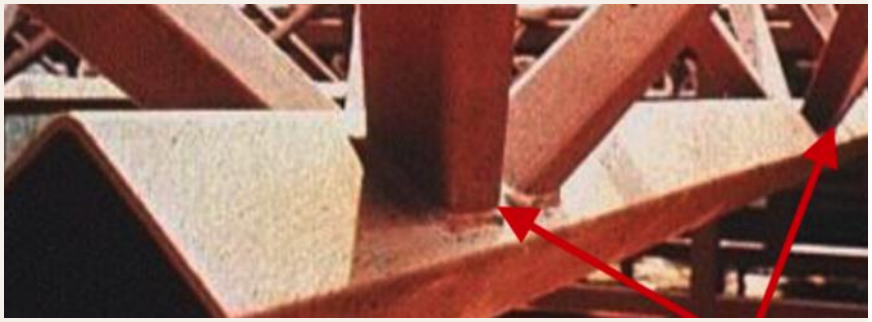
TABLE 5–2 Continued

Types of Connection	Reaction	Number of Unknowns
(5)  single journal bearing		 4 unknowns: 2 forces, 2 couple-moments*
(6)  single journal bearing with square shaft		5 unknowns: 2 forces, 3 couple-moments* 
(7)  single thrust bearing		 5 unknowns: 3 forces, 2 couple-moments*

Bearings: Support shafts

* Couple-moments are not applied to FBD if the body is supported elsewhere by additional bearings, pins or hinges that are **properly aligned** to prevent rotation in one or more axes).

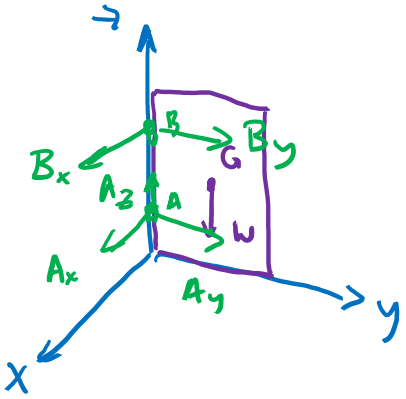
TABLE 5–2 Continued

Types of Connection	Reaction	Number of Unknowns
(8)  single smooth pin		
(9)  single hinge		
(10)  fixed support		

6 unknowns: 3 forces, 3 couple-moments

Note: for fixed supports, must always apply couple-moments to FBD

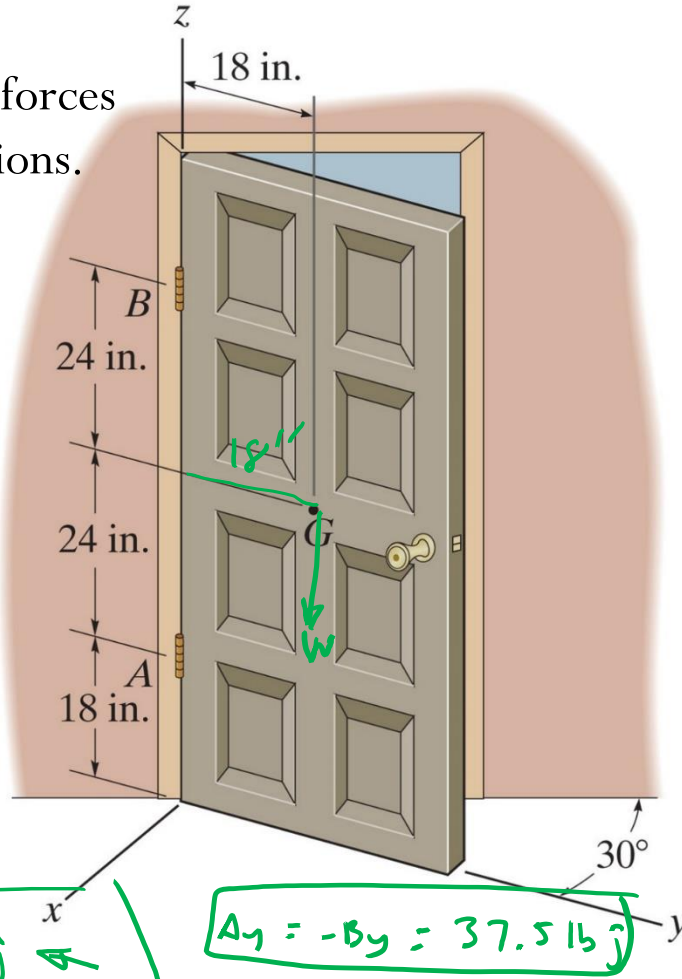
The 100 lb door has its center of gravity at *G*. Determine the components of reaction at hinges *A* and *B* if hinge B resists only forces in the x and y directions and A resists forces in the x, y, z directions.



Assume properly aligned
⇒ No Moments on FBD

Assume hinge A is resisting translation in z-axis, but not hinge B.

Unknowns: 5



SOLN:

ΣF_x: $A_x + B_x = 0$ $\quad A_x = B_x$

ΣF_y: $A_y + B_y = 0$ $\quad A_y = -B_y$

ΣF_z: $A_z - W = 0$

$\boxed{A_z = W = 100 \text{ lb}\ \hat{k}\ \uparrow}$

$+\circlearrowleft \Sigma M_x$: $-18''A_y - 66''B_y - 18''W = 0$

$-18''(-B_y) - 66''B_y - 18''W = 0$

$\boxed{B_y = -37.5 \text{ lb}\ \hat{j}}$ ⇐

$\boxed{A_y = -B_y = 37.5 \text{ lb}\ \hat{j}}$ ⇒

$+\circlearrowright \Sigma M_y$: $18''A_x + 66''B_x = 0$

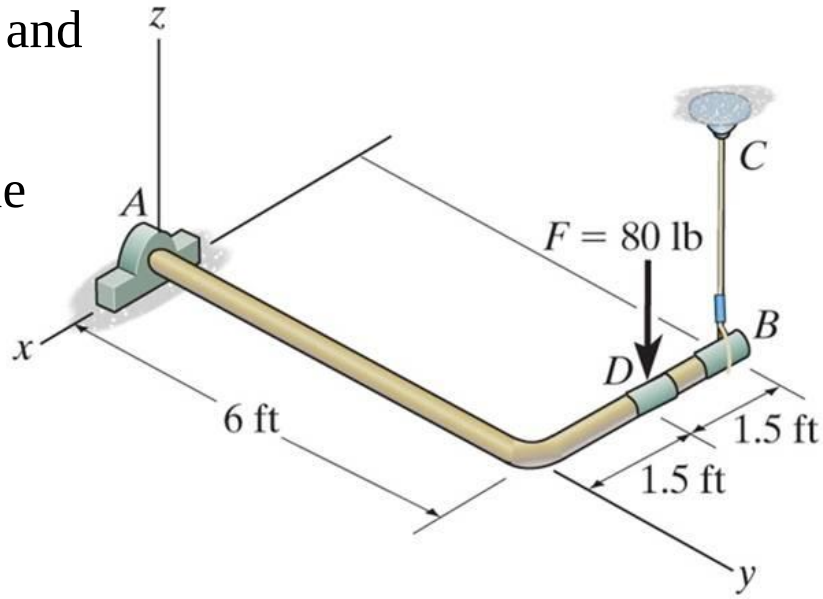
$18(-B_x) + 66B_x = 0$

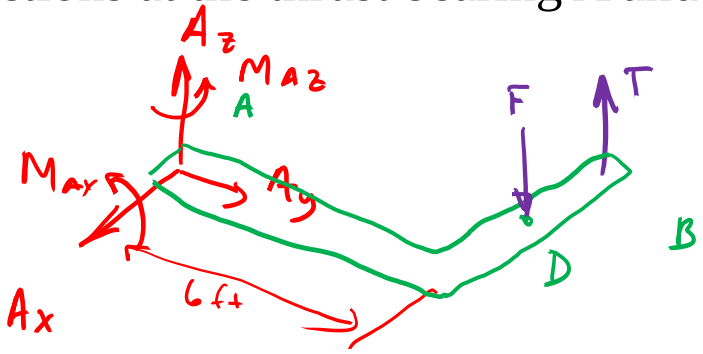
$48B_x = 0$

$\boxed{B_x = 0}$ $\quad \boxed{A_x = 0}$

Given: The rod, supported by thrust bearing at A and cable BC, is subjected to an 80 lb force.

Find: Reactions at the thrust bearing A and cable BC.



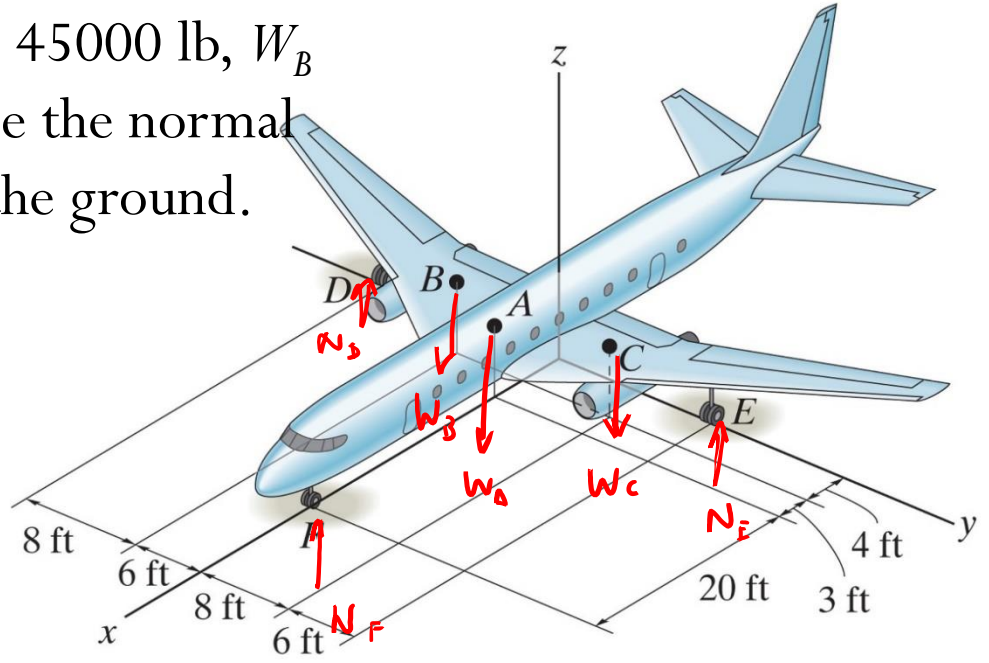


6 unknowns: $T, A_x, A_y, A_z, M_{Ax}, M_{Az}$ ⇒ use all 6 eqns

$$\Sigma M_x: \quad M_{Ax} - (6\text{ ft})F + (6\text{ ft})T = 0$$

Answers: $A_x = 0$, $A_y = 0$, $A_z = 40\text{ lb}\,\hat{k}\uparrow$, $T = 40\text{ lb}\,\hat{k}\uparrow$, $M_{Ax} = 240\text{ ft}\cdot\text{lb}\,\hat{i}$, $M_{Az} = 0$

If these components have weights $W_A = 45000$ lb, $W_B = 8000$ lb and $W_C = 6000$ lb, determine the normal reactions of the wheels D, E, and F on the ground.



Unknowns: 3 N_D, N_E, N_F

can solve with 3 eqns

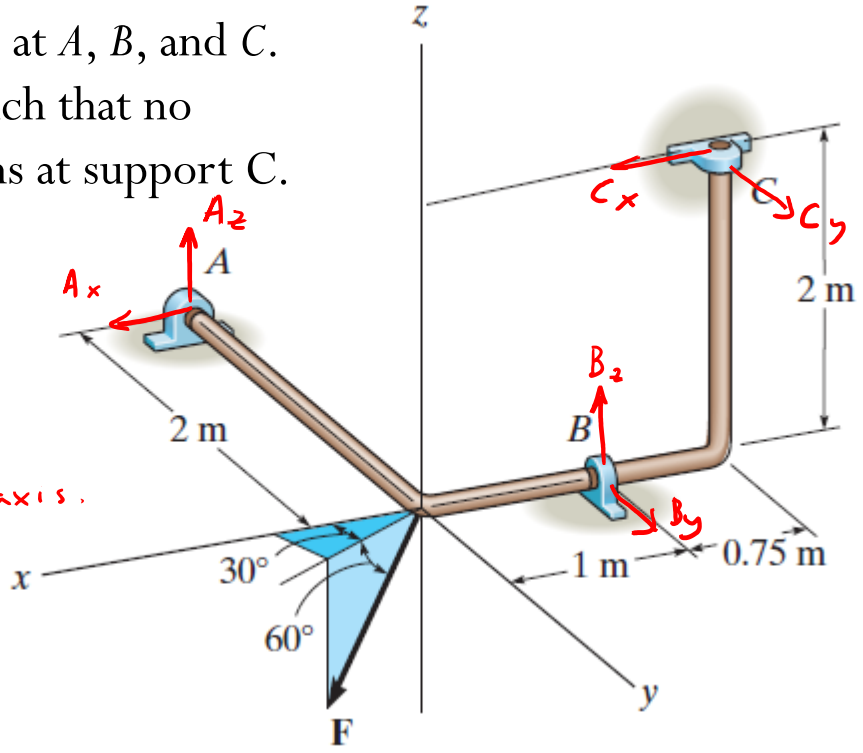
Answers: $N_D = 22.6$ kip $\hat{k}$

$N_E = 22.6$ kip $\hat{k}$

$N_F = 13.7$ kip $\hat{k}$

kip = kilopound = 1000 lb

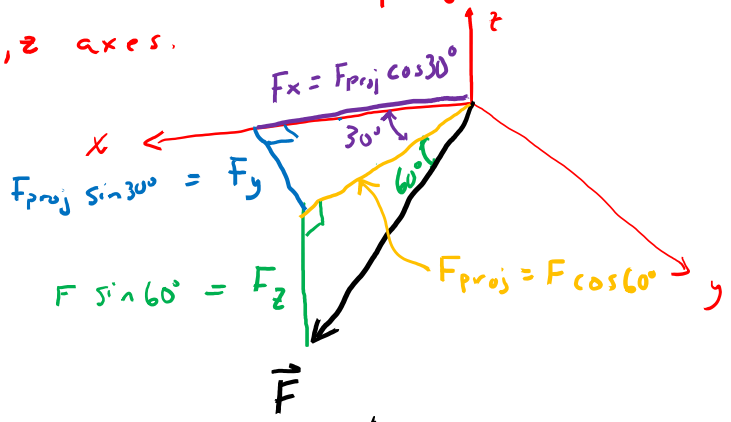
A bent rod is supported by smooth journal bearings at A, B, and C. $F = 800$ N. The supports are **properly aligned** such that no moment support is present. Determine the reactions at support C.



Pointers for this problem:

1) Bearings are properly aligned
   ⇒ No couple-moments at bearings
   Since JOURNAL bearings, only have reaction forces in axes ⊥ to shaft axis.

2) For applied force $\vec{F}$, need to consider how $\vec{F}$ will project onto x, y, z axes.



$$\vec{F} = F_x\,\hat{i} + F_y\,\hat{j} + F_z\,\hat{k}$$

$$\vec{F} = (F\cos 60°)\cos 30°\,\hat{i} + (F\cos 60°)\sin 30°\,\hat{j} - F\sin 60°\,\hat{k}$$