Statics - TAM 210 & TAM 211

Lecture 13

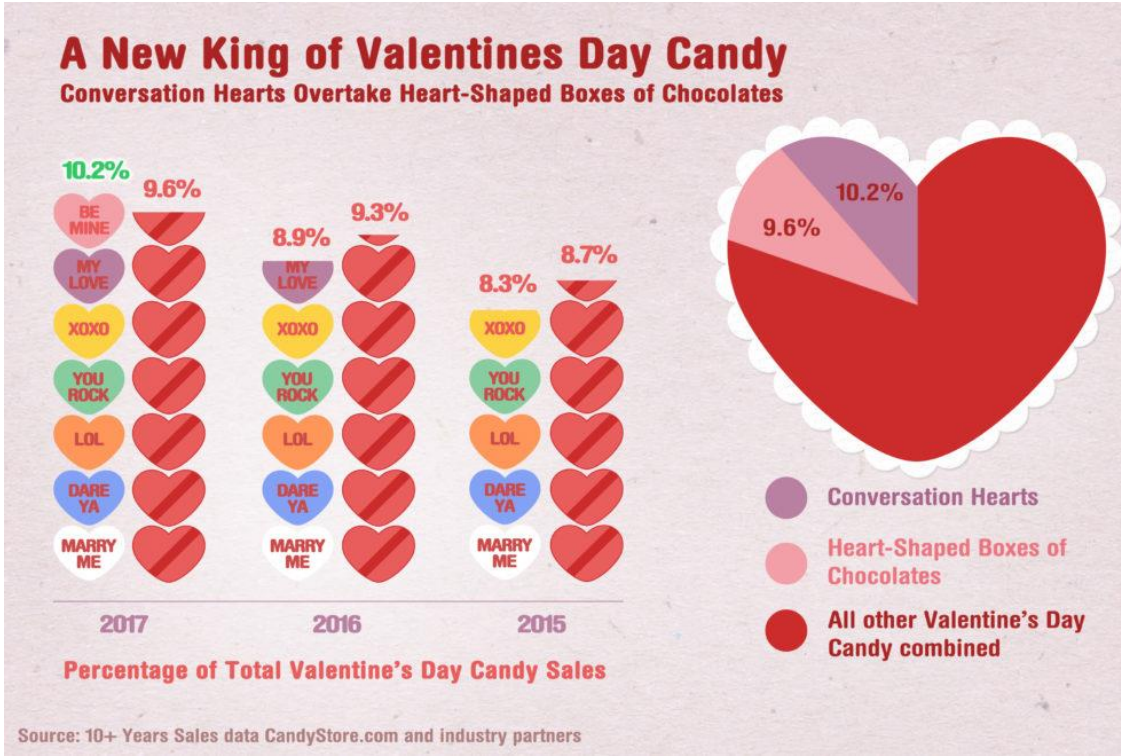
February 14, 2018

Announcements

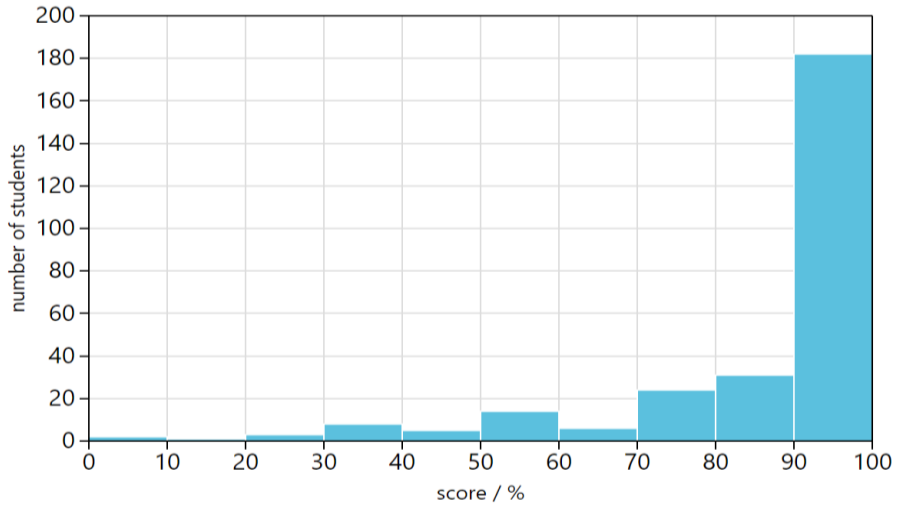
- **READ Piazza posts!** If you had difficulty with Quiz 2, start reading and creating posts. There is a direct correlation with reviewing posts and quiz grade.
- Cumulative exam, Thursday, April 5, 7-9pm, 1 Noyes Lab
  - If you need DRES accommodation, send private message to instructors on Piazza with PDF of DRES letter. You must make your own arrangements at DRES testing facilities.
  - Conflict exam request: **MUST** send private message instructors on Piazza **now or at least 2 weeks before the exam date**. Only legitimate conflicts will be allowed. See Information tab > Exam

- Upcoming deadlines:
  - Written Assignment 2 (2/15)
  - Friday (2/16)
    - Mastering Engineering Tutorial 6

• Quiz 3 (W-F)

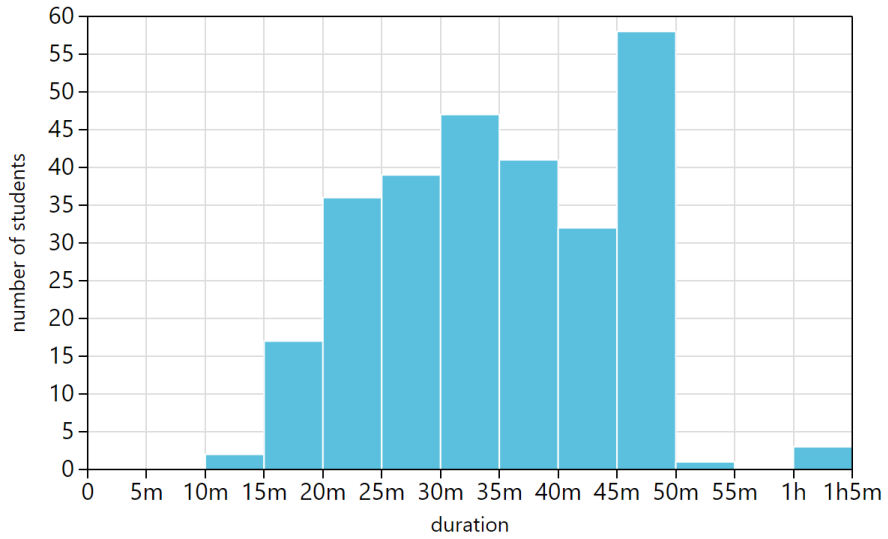


Quiz 1: Score statistics



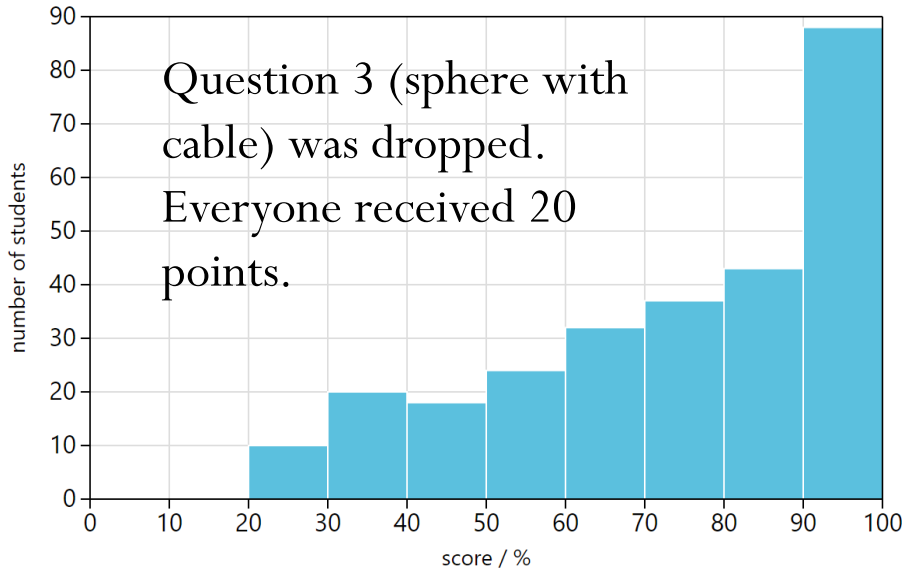
Number of students	276
Mean score	86%
Standard deviation	20%

Quiz 1: Duration statistics



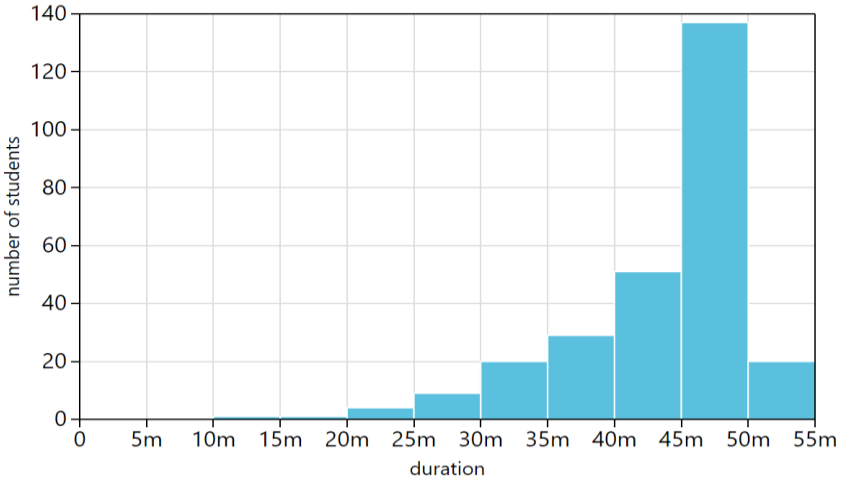
Mean duration	35m
Median duration	34m
Minimum duration	13m

Quiz 2: Score statistics



Number of students	272
Mean score	73%
Standard deviation	23%

Quiz 2: Duration statistics



Mean duration	44m
Median duration	46m
Minimum duration	13m

- Practice PL HW on your own
- Monitor your time
- Read each question, write givens, unknowns, draw FBD, write out equations
- Exam reflections
  - What did you do to prepare for the quiz?
  - What concepts did you struggle with?
  - What can you do differently to prepare for the next quiz?

Chapter 5: Equilibrium of Rigid Bodies

Focus on 2D problems

Sections 5.1-5.4, 5.7

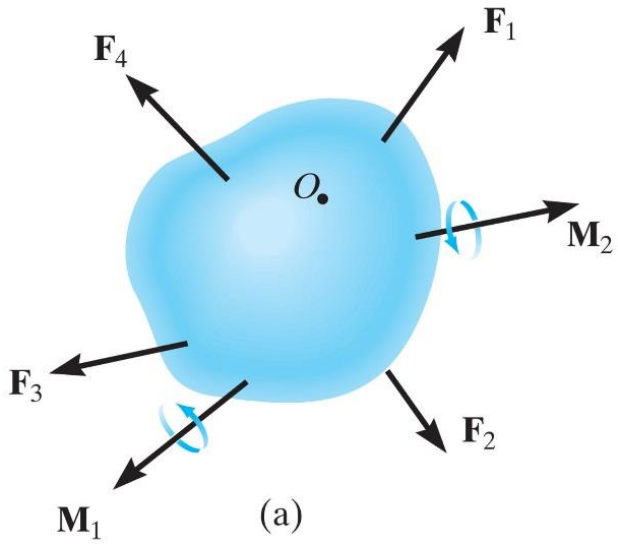
TAM 211 students will cover 3D problems (sections 5.5-5.6) in week 13

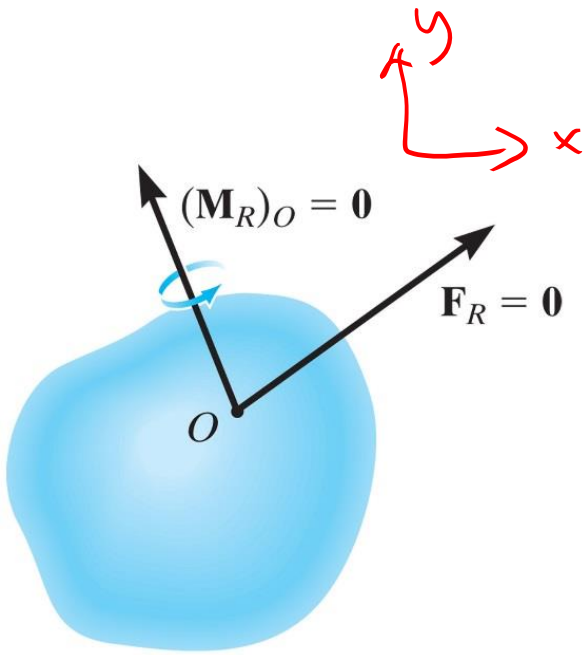
Goals and Objectives

- Introduce the free-body diagram for a 2D rigid body
- Develop the equations of equilibrium for a 2D rigid body
- Solve 2D rigid body equilibrium problems using the equations of equilibrium
- Introduce concepts of
  - Support reactions
  - Two- and three-force members
  - Constraints and statical determinacy

Recap: Equilibrium of a Rigid Body

Reduce forces and couple moments acting on a body to an equivalent resultant force and a resultant couple moment at an arbitrary point O.





$\Sigma \vec{F}_x = 0$

$\Sigma \vec{F}_y = 0$

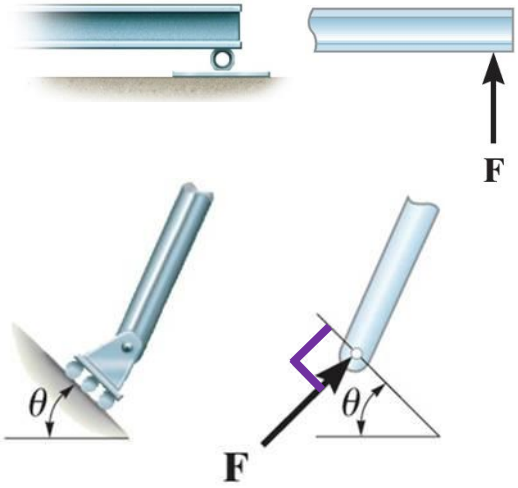
$$\overrightarrow{F_R} = \sum \vec{F} = 0$$

$$(\overrightarrow{M_R})_O = \sum \overrightarrow{M_O} = 0$$

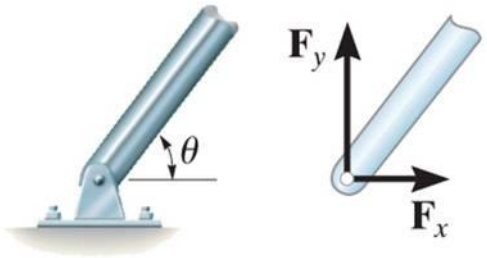
$+\circlearrowleft \Sigma \vec{M}_o$

Recap: Equilibrium in two-dimensional bodies (Support reactions)

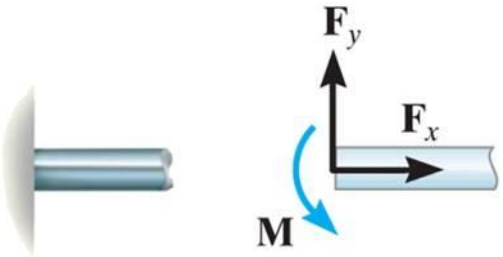
Roller



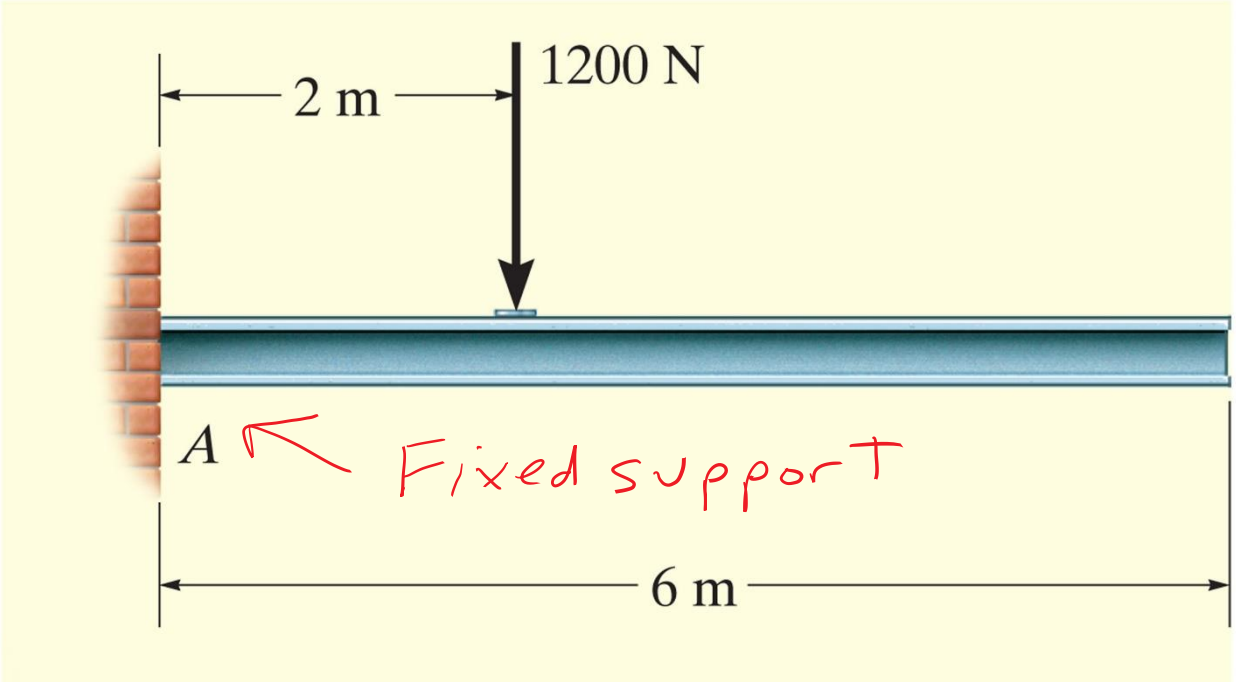
Smooth pin or hinge



Fixed support

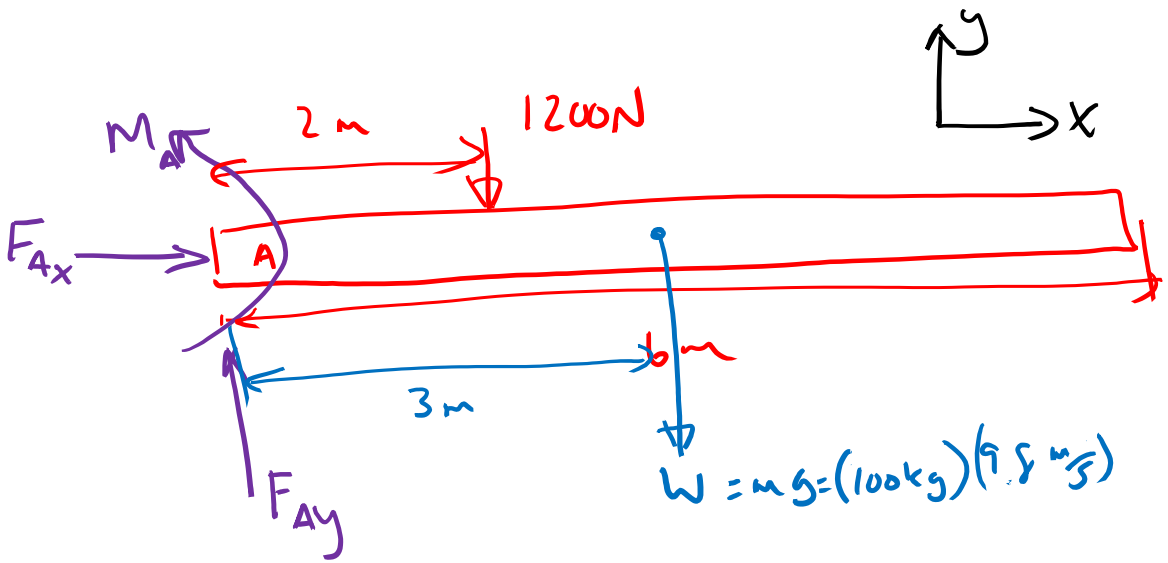


- If a support prevents the translation of a body in a given direction, then a force is developed on the body on that direction
- If a rotation is prevented, a couple moment is exerted on the body



Beam has mass of 100 kg and experiences load of 1200 N. Identify support reaction type. Find support reactions at A.

- Fixed support
- Draw FBD before writing equations



3 unknowns:
F_{Ax}, F_{Ay}, M_A

Solve w/ 3 eqns

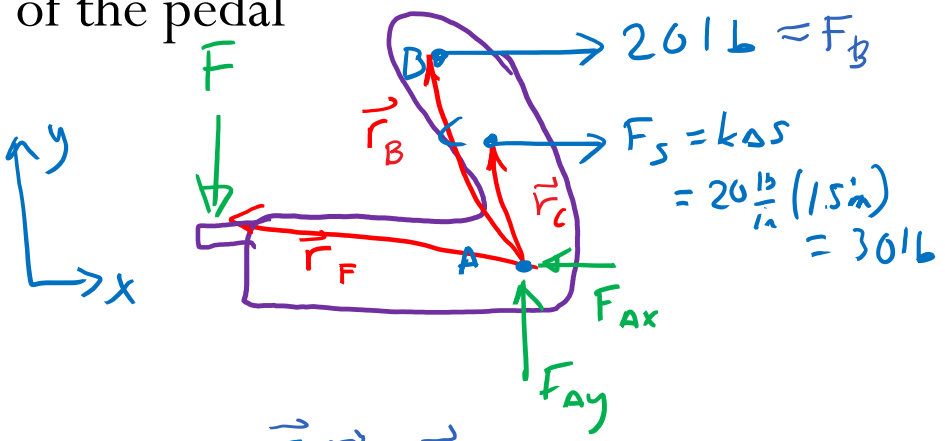
ΣF_x:

ΣF_y:

ΣM_A:

See Example 5.1 in text

The operator applies a vertical force to the pedal so that the spring is stretched 1.5 in. and the force in the short link at B is 20 lb. Draw the FBD of the pedal



unknowns: $\vec{F}, \vec{F}_{Ax}, \vec{F}_{Ay}$

Directions of arrows of unknown forces/moments are arbitrary on FBD. Actual direction be determined with solution for unknown values

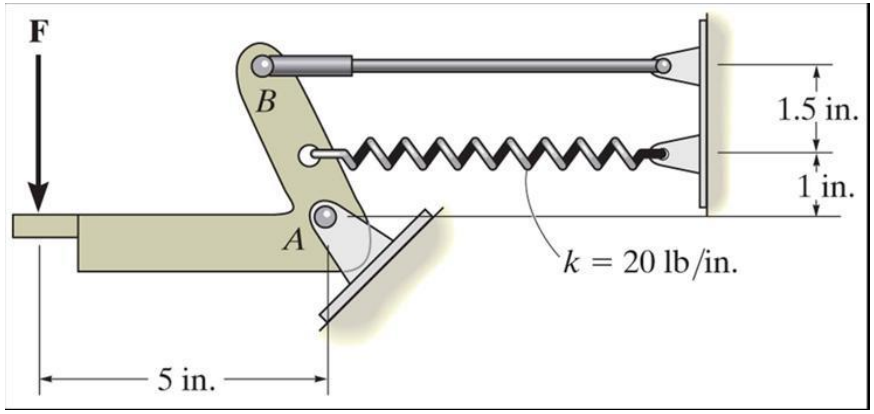
ΣF_x

ΣF_y

$\Sigma M_{Pt?}$: What point to select to compute moment?

Pt A is good choice because $\vec{F}_{Ax}$ & $\vec{F}_{Ay}$ do not contribute to moment about A.

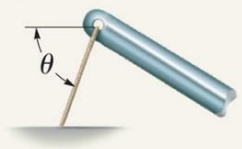
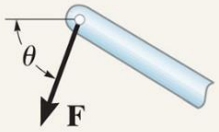
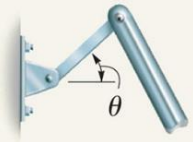
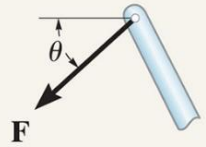
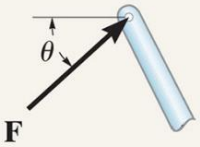
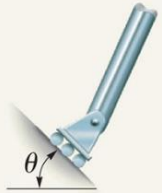
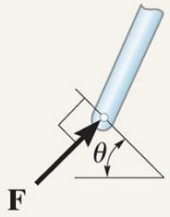
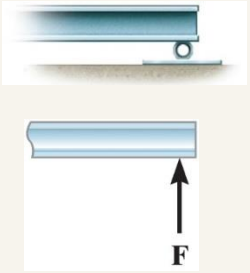
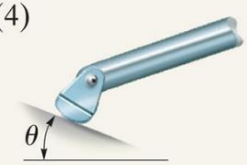
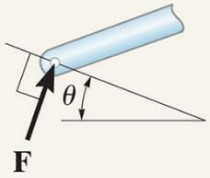
$\therefore \Sigma M_A : \vec{r}_F \times \vec{F} + \vec{r}_B \times \vec{F}_B + \vec{r}_C \times \vec{F}_s = 0$



See Example 5.2 in text

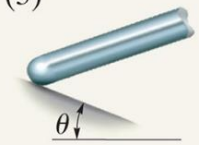
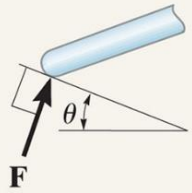
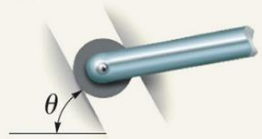
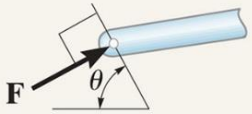
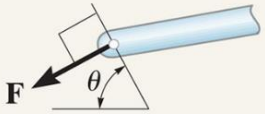
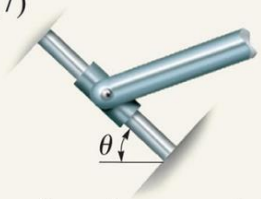
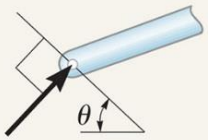
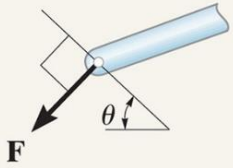
Types of connectors/supports

TABLE 5–1 Supports for Rigid Bodies Subjected to Two-Dimensional Force Systems

Types of Connection	Reaction	Number of Unknowns
(1)  cable		One unknown. The reaction is a tension force which acts away from the member in the direction of the cable.
(2)  weightless link	 or 	One unknown. The reaction is a force which acts along the axis of the link.
(3)  roller	 	One unknown. The reaction is a force which acts perpendicular to the surface at the point of contact.
(4)  rocker		One unknown. The reaction is a force which acts perpendicular to the surface at the point of contact.

Types of connectors/supports

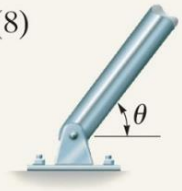
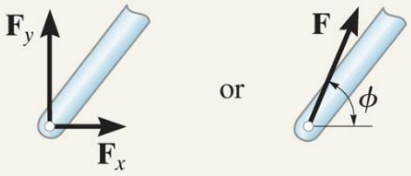
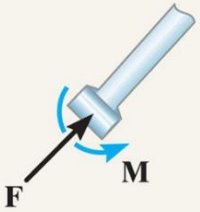
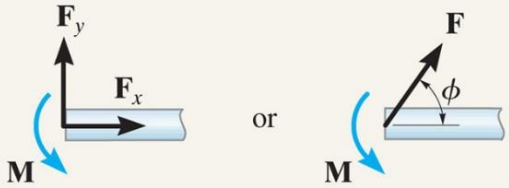
TABLE 5–1 Supports for Rigid Bodies Subjected to Two-Dimensional Force Systems

Types of Connection	Reaction	Number of Unknowns
(5)  smooth contacting surface		One unknown. The reaction is a force which acts perpendicular to the surface at the point of contact.
(6)  roller or pin in confined smooth slot	 or 	One unknown. The reaction is a force which acts perpendicular to the slot.
(7)  member pin connected to collar on smooth rod	 or 	One unknown. The reaction is a force which acts perpendicular to the rod.

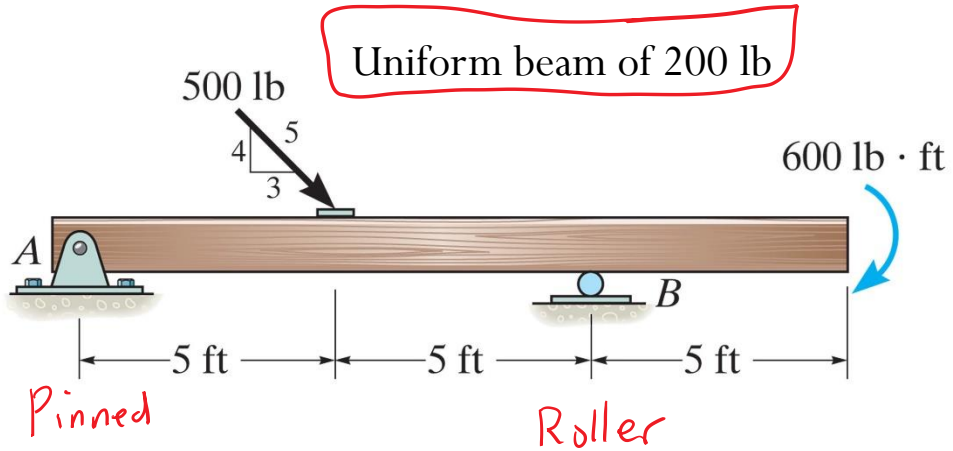
continued

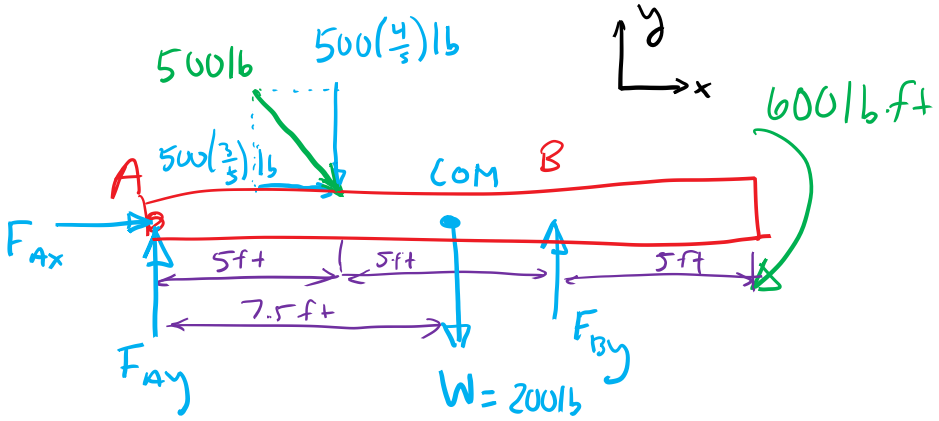
Types of connectors/supports

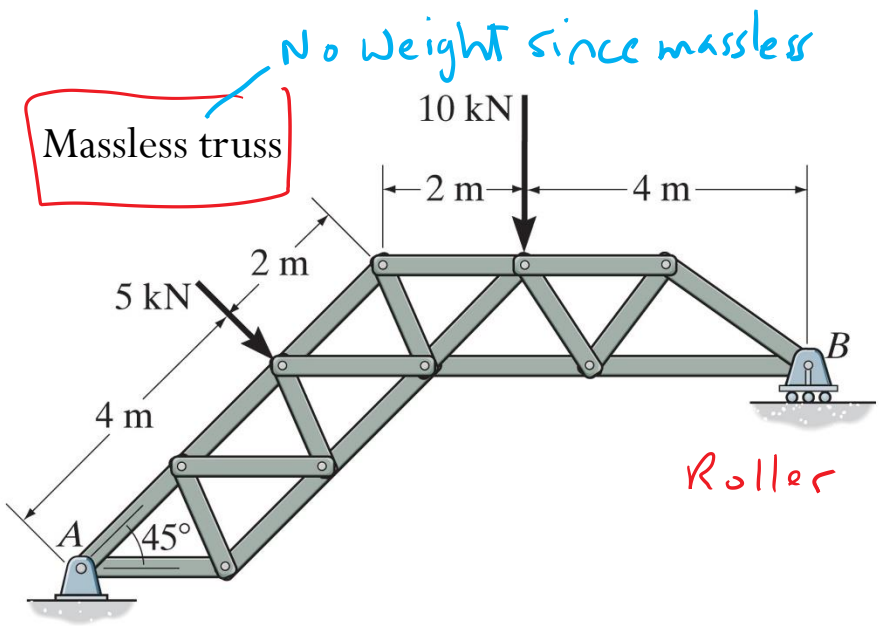
TABLE 5–1 Continued

Types of Connection	Reaction	Number of Unknowns
(8)  smooth pin or hinge		Two unknowns. The reactions are two components of force, or the magnitude and direction ϕ of the resultant force. Note that ϕ and θ are not necessarily equal [usually not, unless the rod shown is a link as in (2)].
(9)  member fixed connected to collar on smooth rod		Two unknowns. The reactions are the couple moment and the force which acts perpendicular to the rod.
(10)  fixed support		Three unknowns. The reactions are the couple moment and the two force components, or the couple moment and the magnitude and direction ϕ of the resultant force.

Identify support reaction types. Draw the FBD of body AB with forces in Cartesian coordinates.







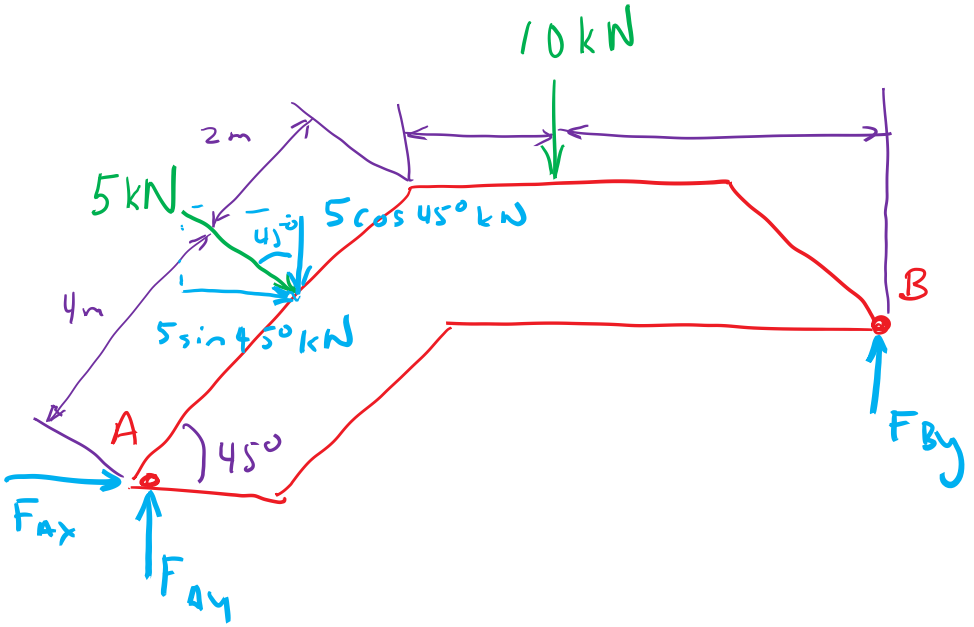
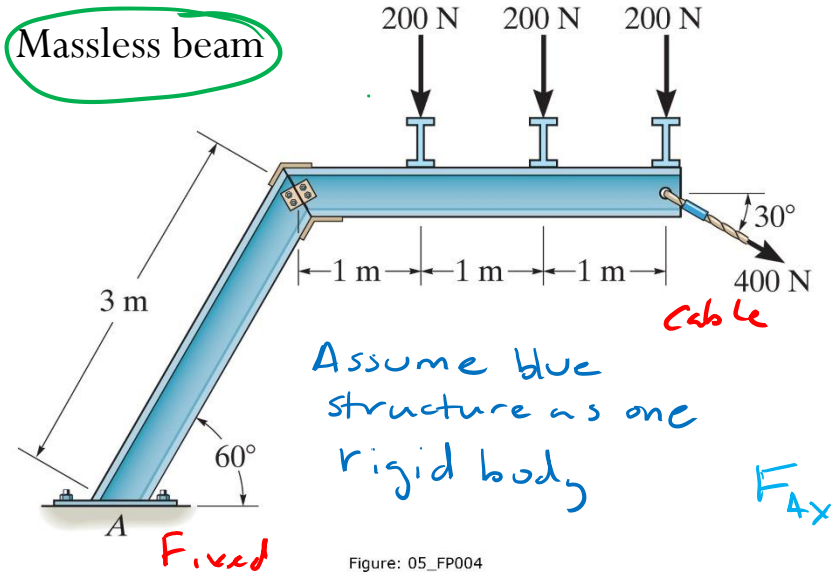


Figure: 05_FP003

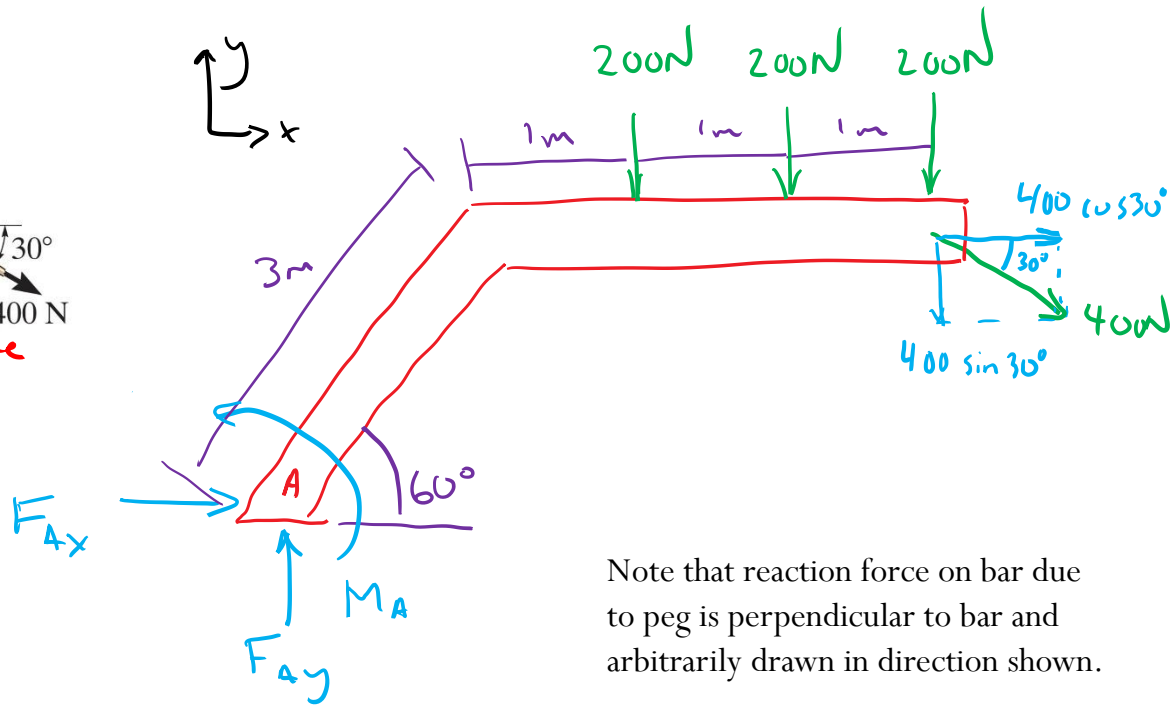
Identify support reaction types. Draw the FBD of rigid body with forces in Cartesian coordinates.

Massless beam



Assume blue structure as one rigid body

Figure: 05_FP004



Note that reaction force on bar due to peg is perpendicular to bar and arbitrarily drawn in direction shown.

25 kg bar with center of mass at G. Supported by smooth peg at C, roller at A, cord AB

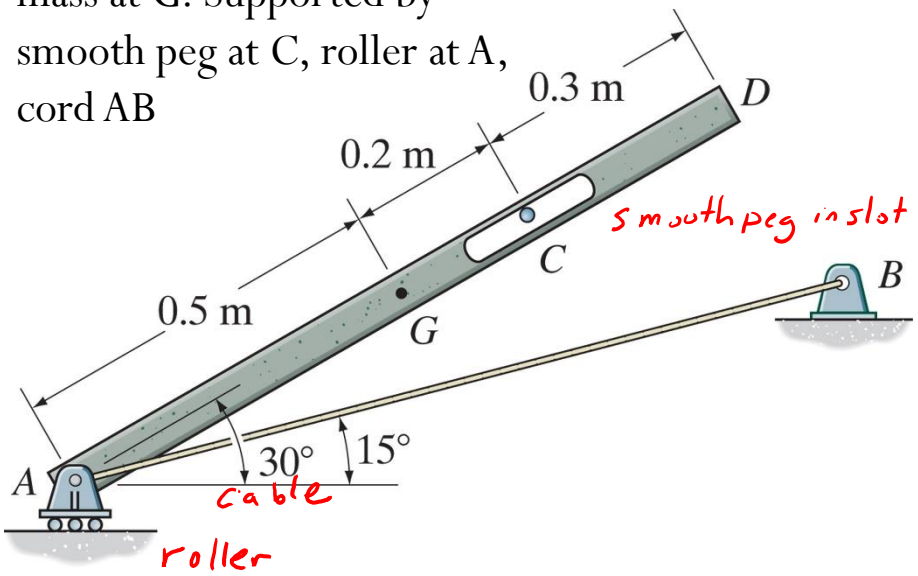
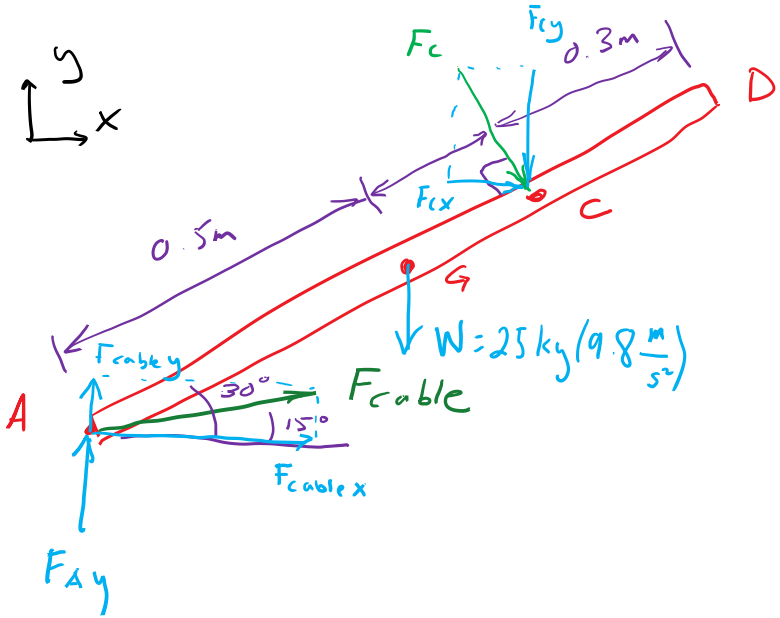
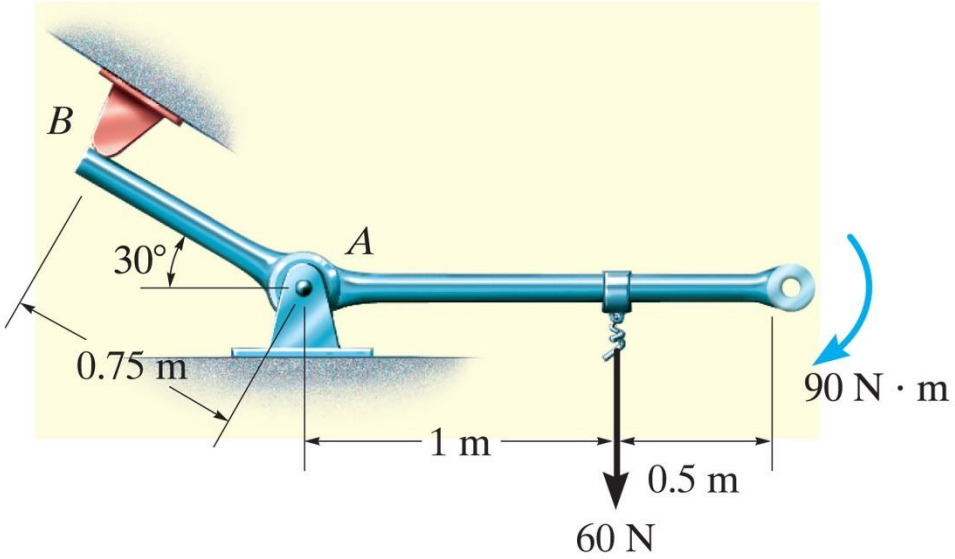


Figure: 05_FP005

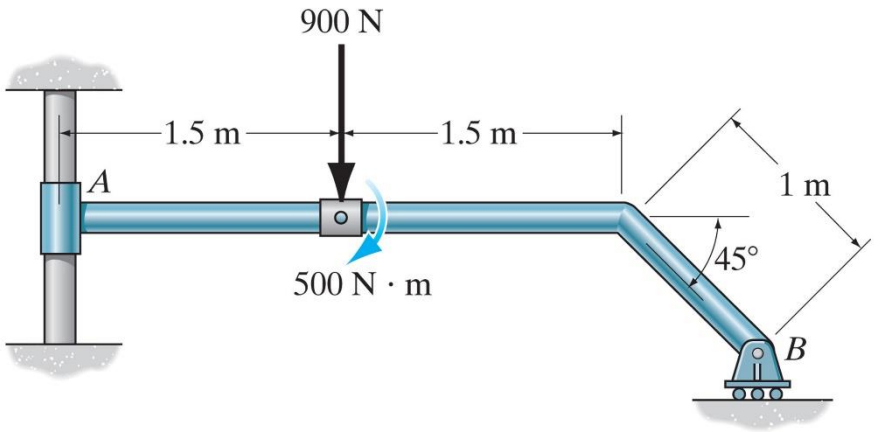


Identify support reaction types. Draw the FBD of blue body with forces in Cartesian coordinates.

Pinned at A, smooth support at B. Neglect mass



Collar at A can slide vertically, roller @ B



Can you draw the FBDs of link AB and roller wheel B?