CE30 – Discussion 3

Couples & Rigid Bodies 2D

Textbook: 3.3 – 4.1

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Homework 3

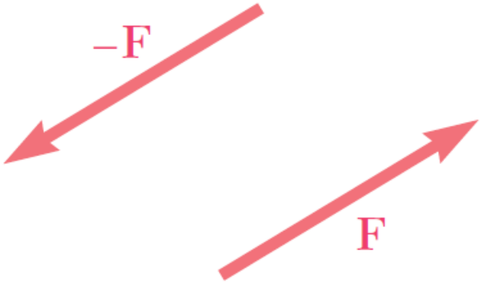
- Problems from the textbook:
  3.39, 3.40, 3.49, 3.60, 3.71, 3.75, and 4.1

- Late Policy: 20% penalty if submitted before Monday midnight
  - No credit after Monday!

- Submit regrade request only through Gradescope
  - Do not email Prof or GSIs

Force Couples

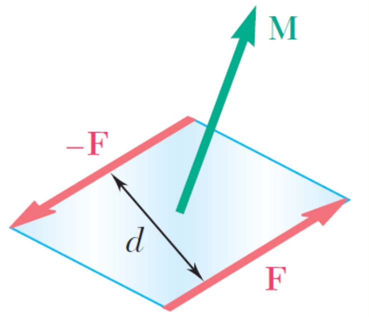
- Two forces $\mathbf{F}$ and $-\mathbf{F}$ said to form a ***couple***, when they have
    1. Equal magnitude
    2. Opposite direction
    3. Parallel line of action



- Net force is zero, but the moment is not!
    – Couples will not move the body, but they will rotate it.

Moment of a Couple

Taking the moment w.r.t. an arbitrary point, we end up with



$$M = F\,d$$

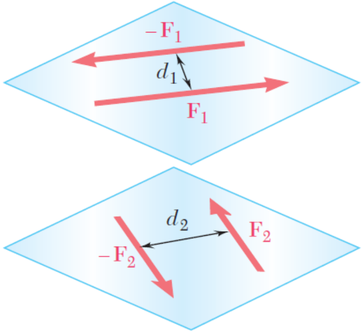
d is the perpendicular distance between the line of action

M is the *moment of the couple*, which is a free vector

Equivalent Couples

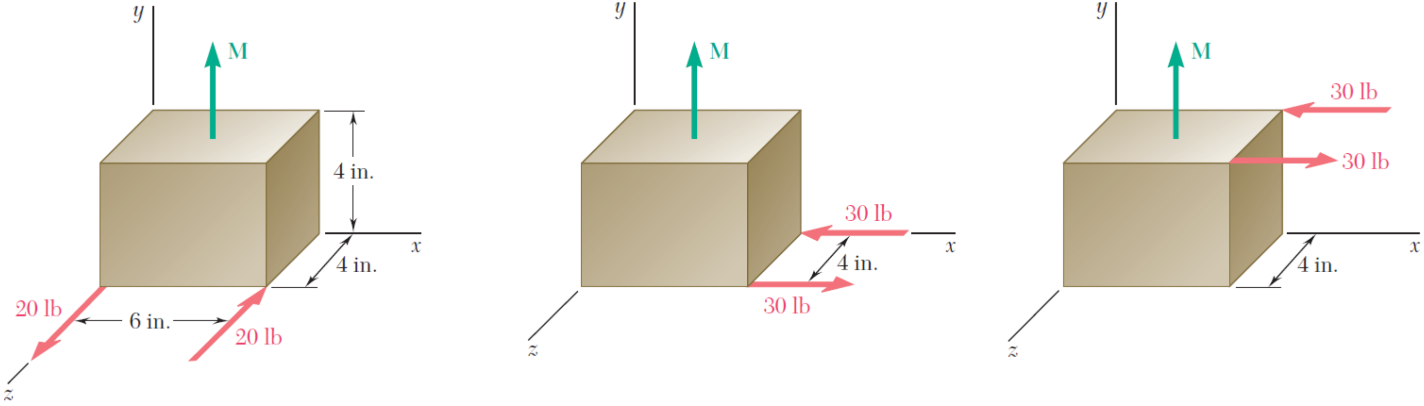
Couples having the same moment

– Have the same effect on a rigid body



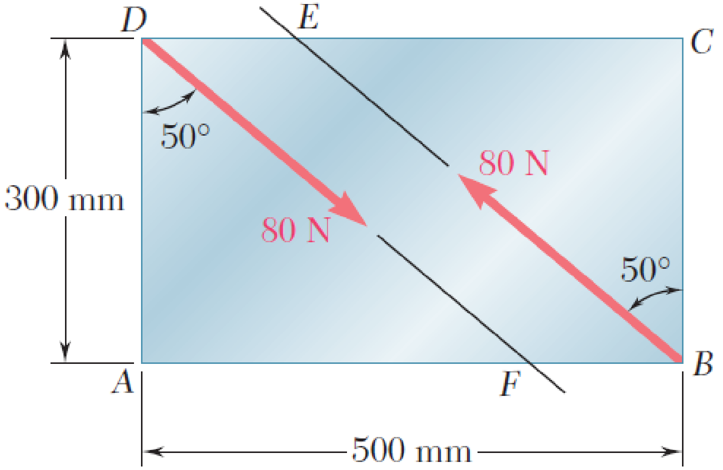
$$F_1 d_1 = F_2 d_2$$

Below systems are equivalent:



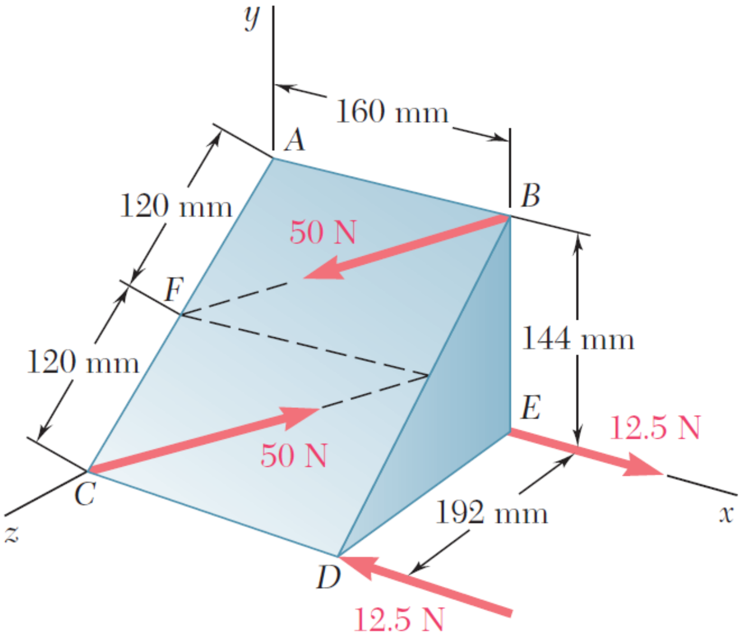
Practice – Similar to HW P3.49

Two 80-N forces are applied as shown to the corners B and D of a rectangular plate. (*a*) Determine the moment of the couple formed by the two forces by resolving each force into horizontal and vertical components and adding the moments of the two resulting couples. (*b*) Use the result obtained to determine the perpendicular distance between lines BE and DF.



Practice – Similar to HW P3.60

Replace the two couples shown by a single equivalent couple, specifying its magnitude and the direction of its axis.



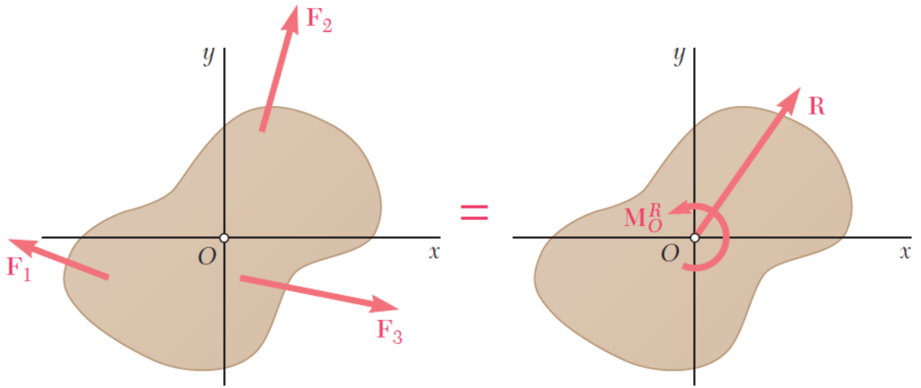
Equivalent System of Forces

Two system of forces $\mathbf{F}_1, \mathbf{F}_2, \ldots$ and $\mathbf{F}_1', \mathbf{F}_2', \ldots$ are equivalent, iff

$$\sum \mathbf{F} = \sum \mathbf{F}' \qquad \text{and} \qquad \sum \mathbf{M}_O = \sum \mathbf{M}'_O$$

Sum of forces are equal

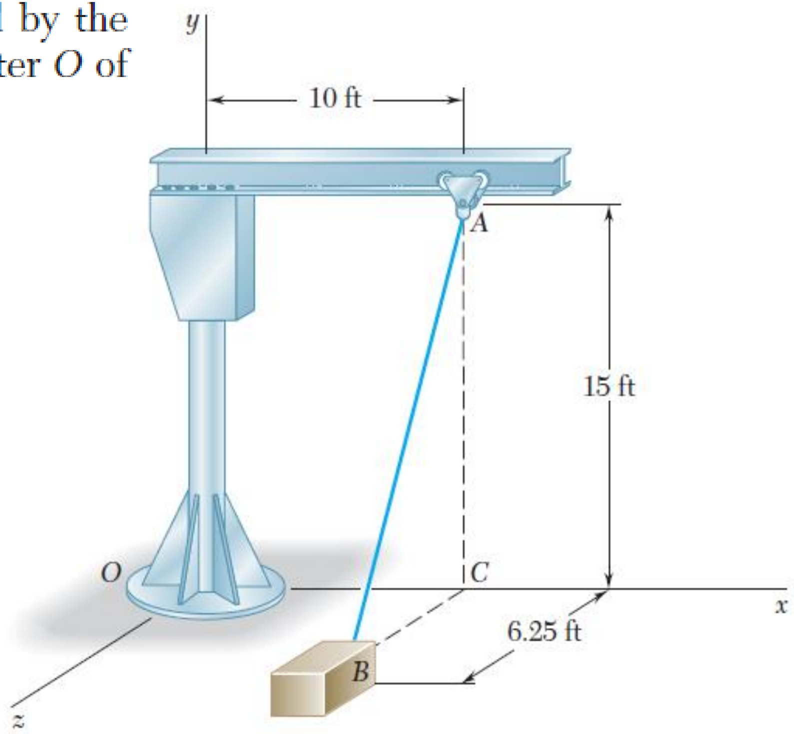
Sum of moments are equal



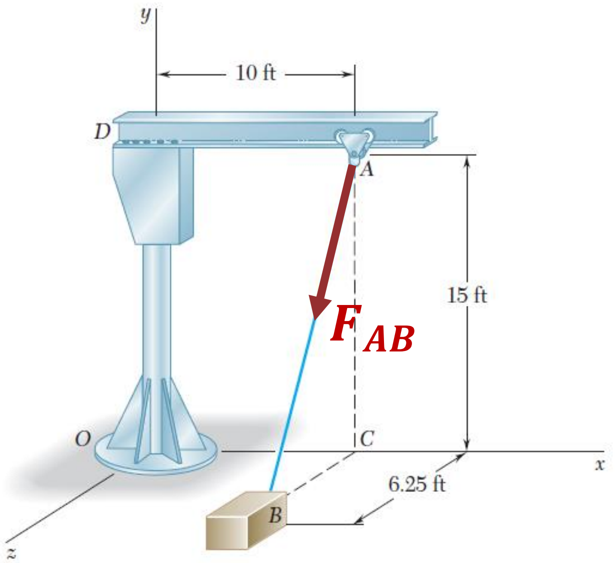
$\mathbf{F}_1$, $\mathbf{F}_2$ and $\mathbf{F}_3$ are reduced to $\mathbf{R}$ and $\mathbf{M}_O$

Practice – Similar to HW P3.71

The jib crane shown is orientated so that its boom AD is parallel to the x axis and is used to move a heavy crate. Knowing that the tension in cable AB is 2.6 kips, replace the force exerted by the cable at A by an equivalent force-couple system at the center O of the base of the crane.



Practice – Similar to HW P3.71



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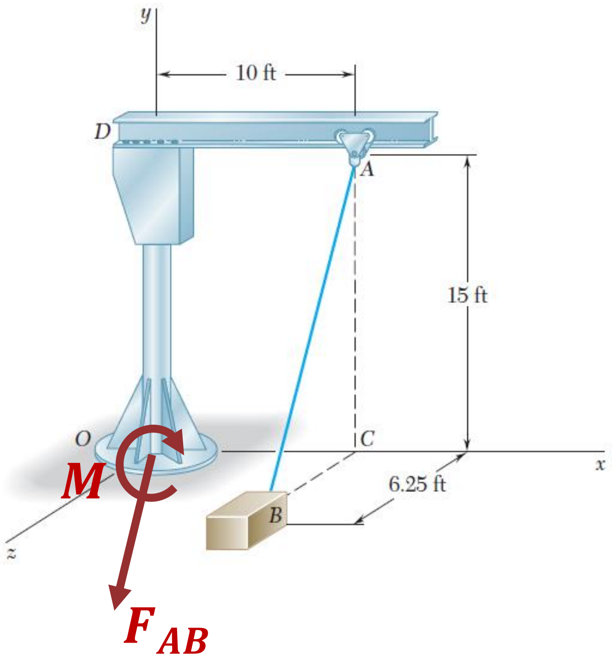
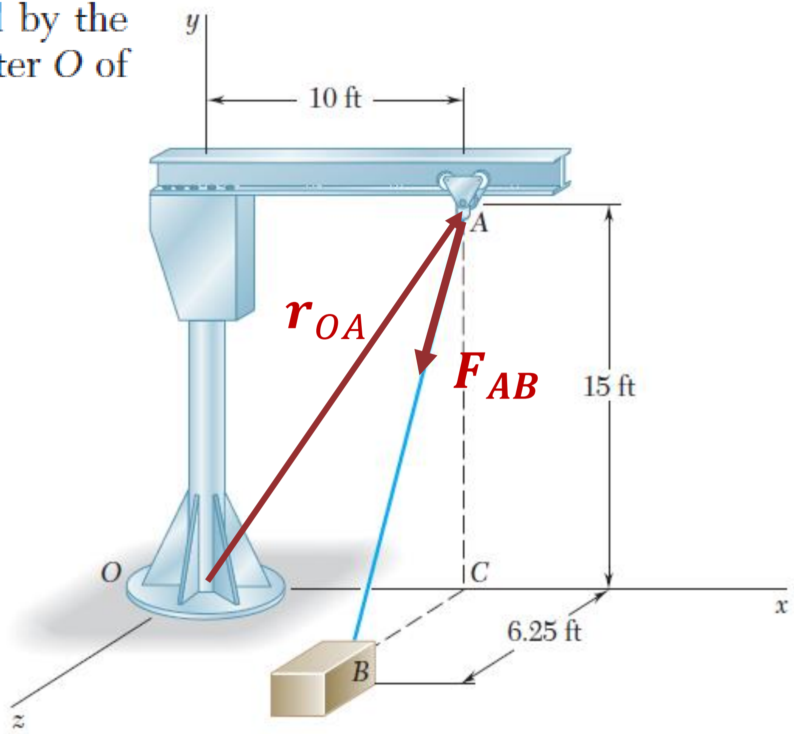


Practice – Similar to HW P3.71

The jib crane shown is orientated so that its boom *AD* is parallel to the *x* axis and is used to move a heavy crate. Knowing that the tension in cable *AB* is 2.6 kips, replace the force exerted by the cable at *A* by an equivalent force-couple system at the center *O* of the base of the crane.

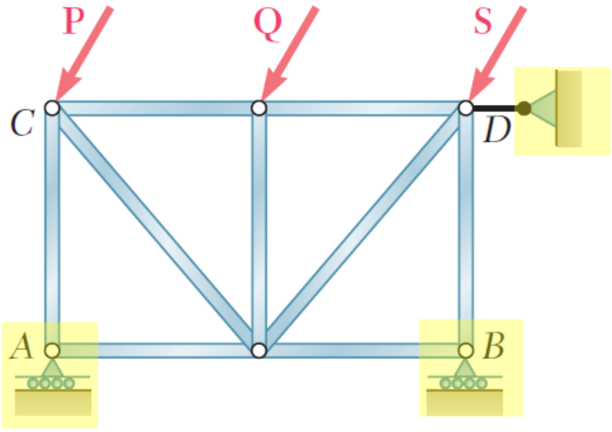


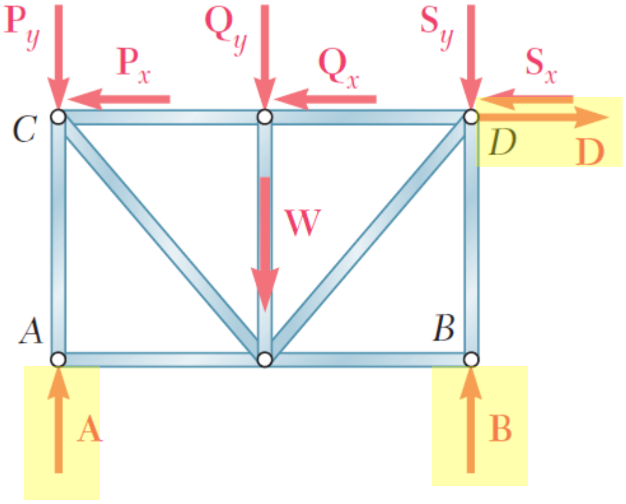
Rigid Body Equilibrium in 2D

Force and moment equilibrium

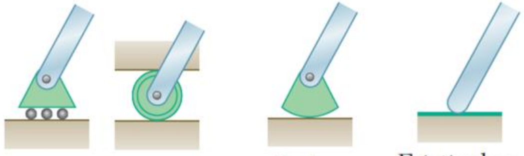
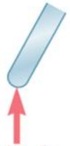
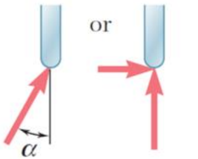
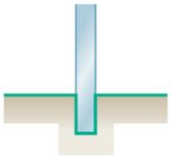
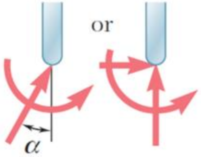
$$\sum F_x = 0 \qquad \sum F_y = 0 \qquad \sum M_A = 0$$

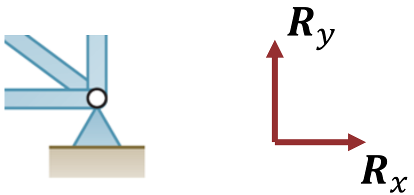
Reaction forces at supports and FBD:

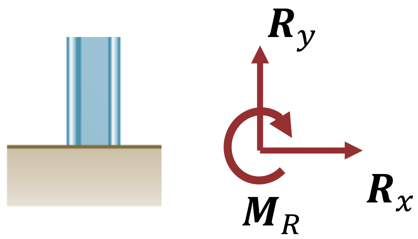




Support Types

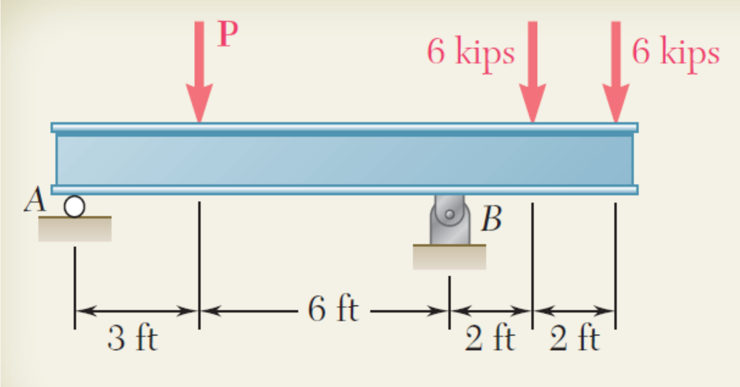
Support or Connection	Reaction	Number of Unknowns
 Rollers, Rocker, Frictionless surface	 Force with known line of action	1
 Frictionless pin or hinge, Rough surface	 Force of unknown direction	2
 Fixed support	 Force and couple	3





Practice - Similar to HW P4.1

Three loads are applied to a beam as shown. The beam is supported by a roller at A and by a pin at B. Neglecting the weight of the beam, determine the reactions at A and B when $P = 15$ kips.



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