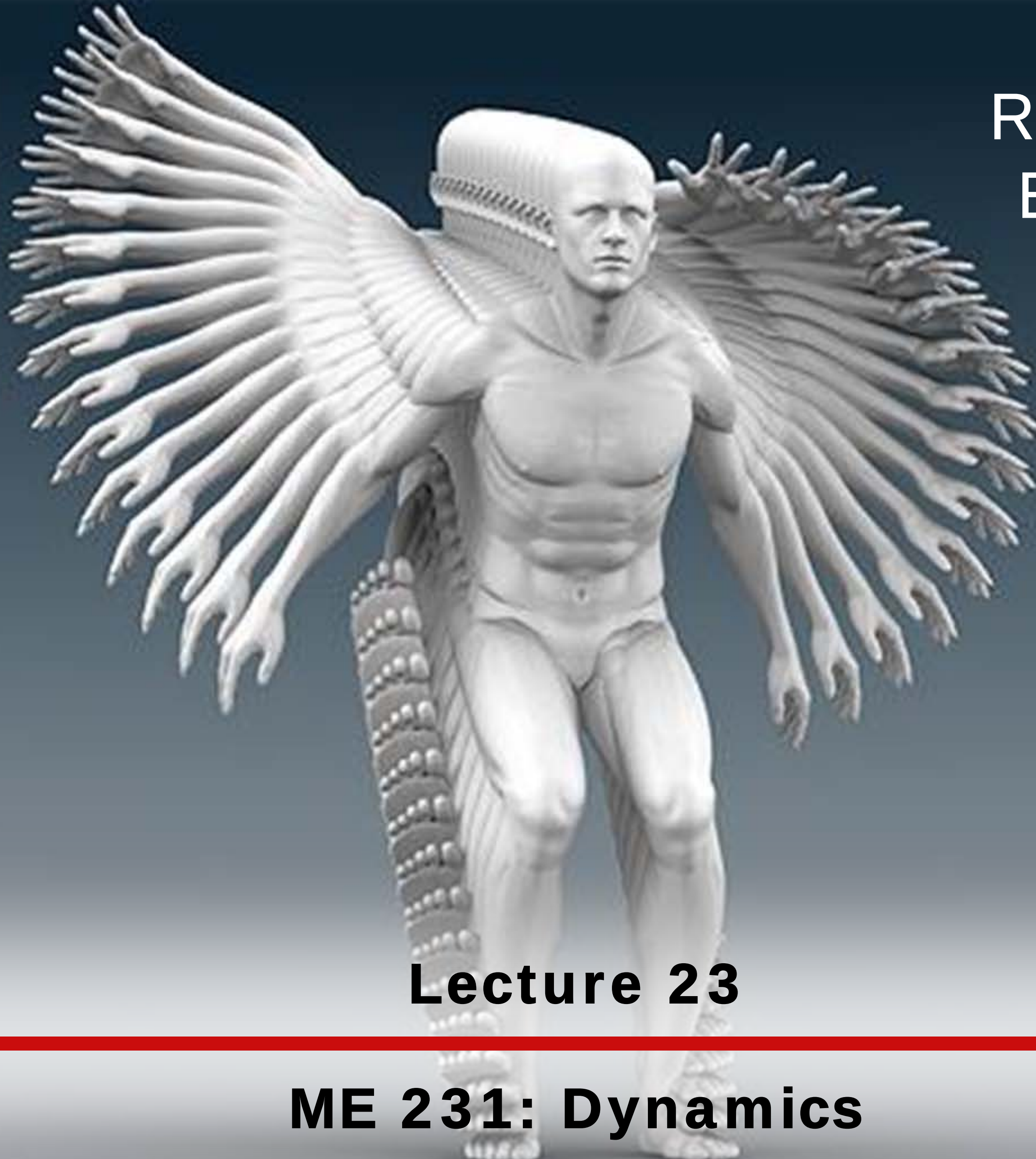


Rigid Body Equations of Motion

Lecture 23

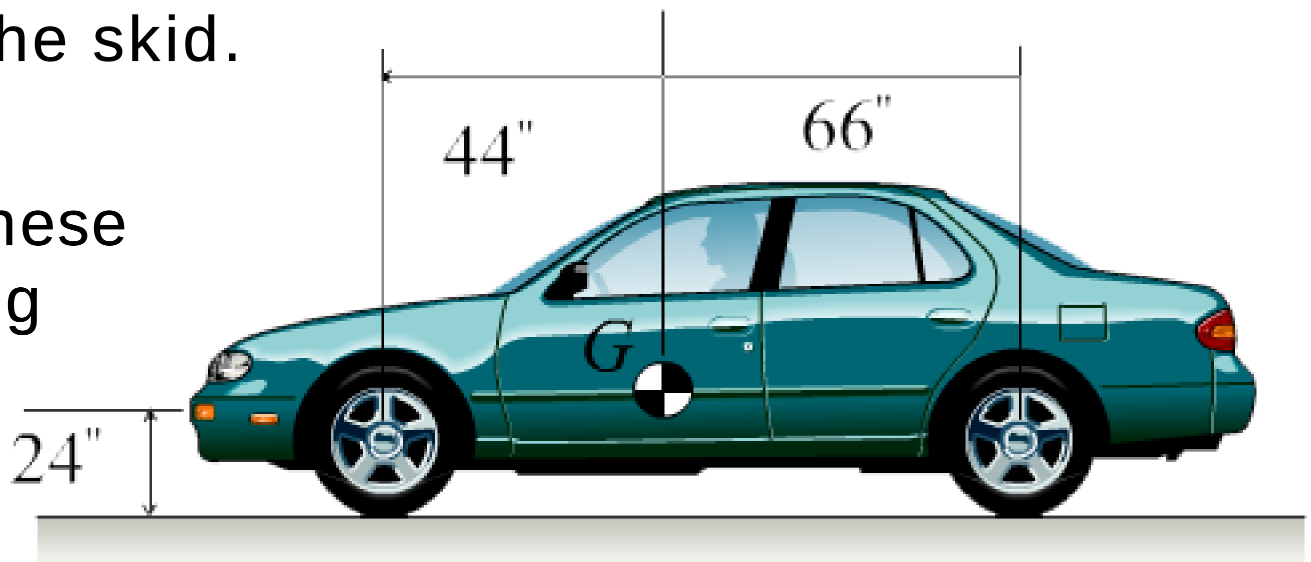
ME 231: Dynamics

Question of the Day

The ***3200-lb*** front-engine car is traveling forward at a constant velocity when the brakes lock up all four wheels. The coefficient of kinetic friction is 0.8 between the tire and the road.

Determine the ***normal force*** under each tire just before the skid.

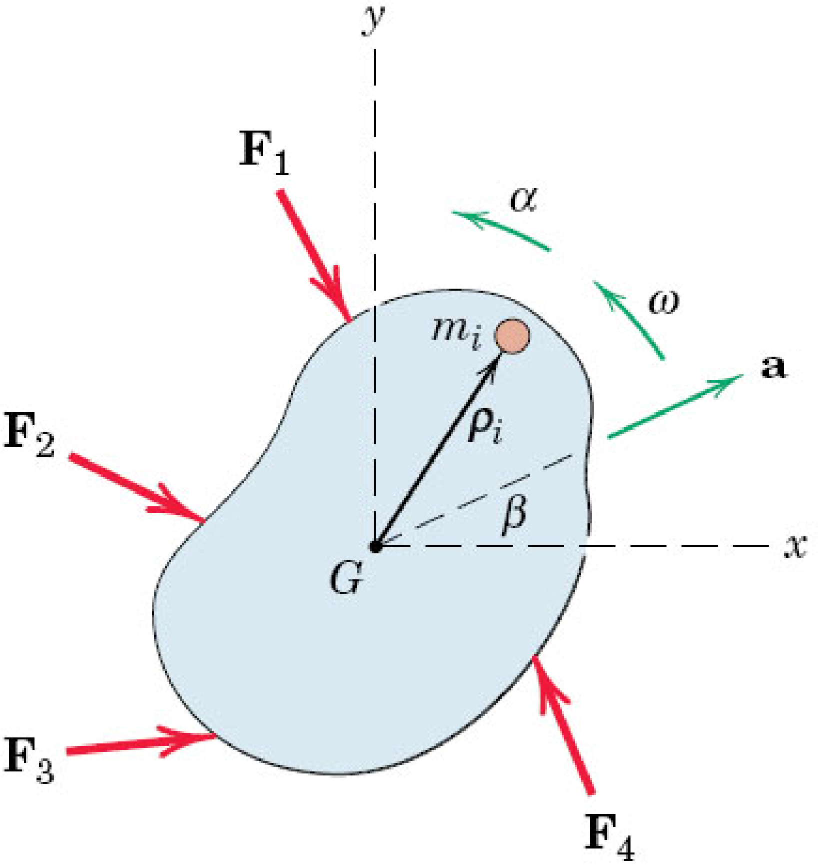
Determine these ***forces*** during the skid.

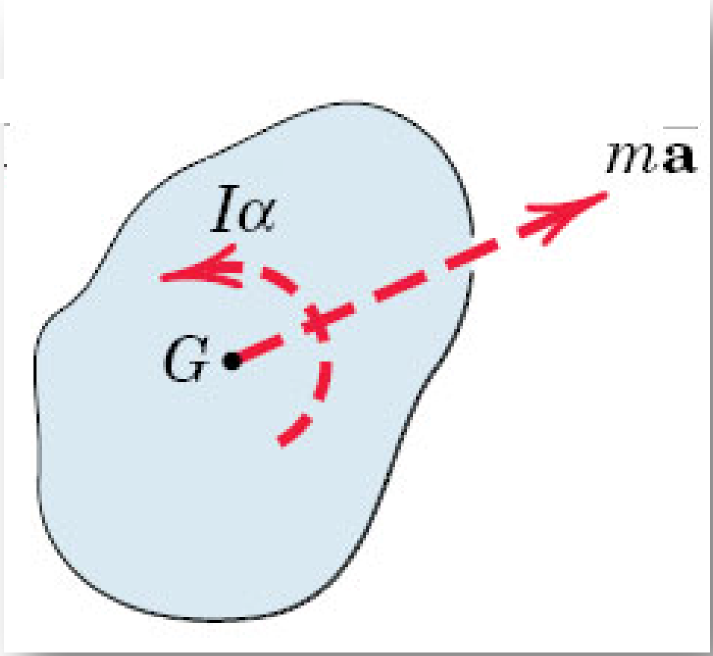


Outline for Today

- Question of the day
- Plane-motion equations (again)
- Unconstrained and constrained motion
- Systems of interconnected bodies
- Step-by-step solution process
- Rigid-body translation
- Answer your questions!

Recall: Plane-Motion Equations





- Rigid body moving in the ***x-y plane***
- Mass center G has an ***acceleration a***
- Body has an ***angular velocity*** ω and ***angular acceleration*** α

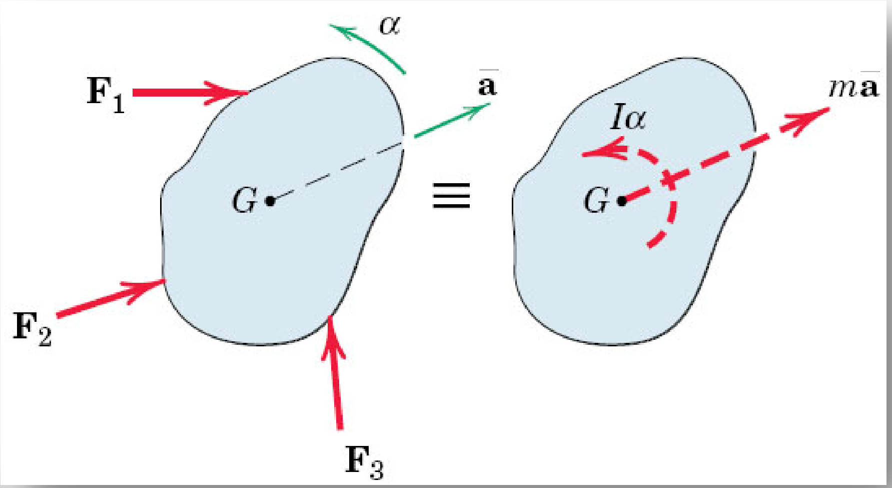
$$\sum \mathbf{F} = m\mathbf{a}$$

$$\sum \mathbf{M}_G = I_G \boldsymbol{\alpha}$$

Recall: Alternative Moment Equations

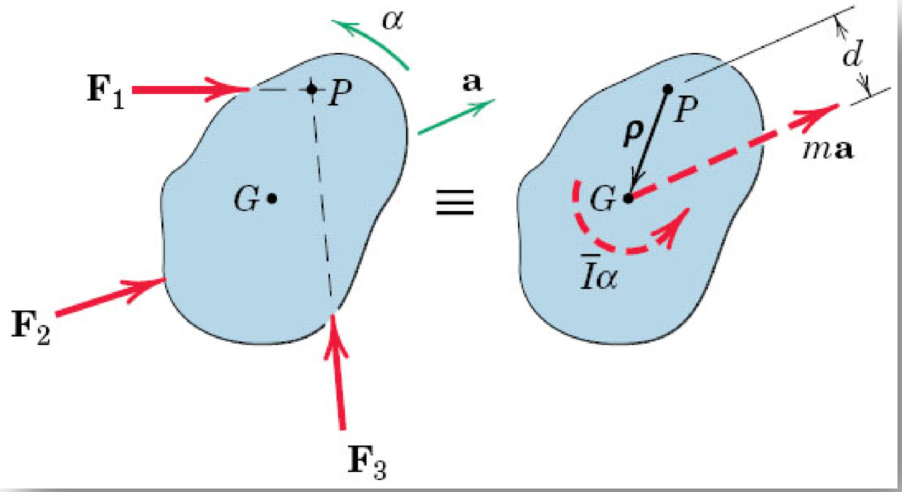
$$\sum \mathbf{F} = m\mathbf{a}$$

Point *G* is mass center



$$\sum \mathbf{M}_G = I_G \boldsymbol{\alpha}$$

Point *P* fixed in the body



$$\sum M_P = I_G \alpha + mad$$

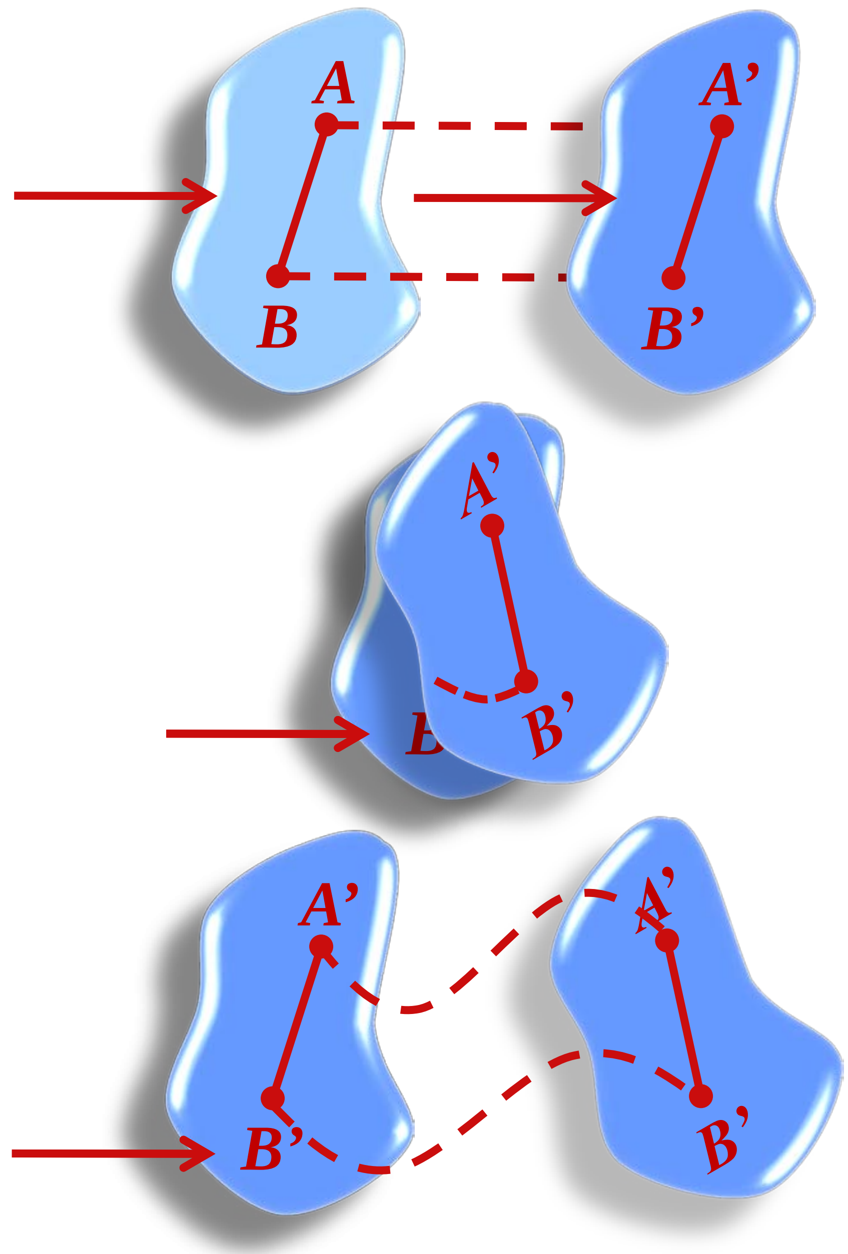
$$\sum \mathbf{M}_P = I_P \boldsymbol{\alpha} + \boldsymbol{\rho} \times m\mathbf{a}_P$$

Point *O* fixed in an inertial reference system

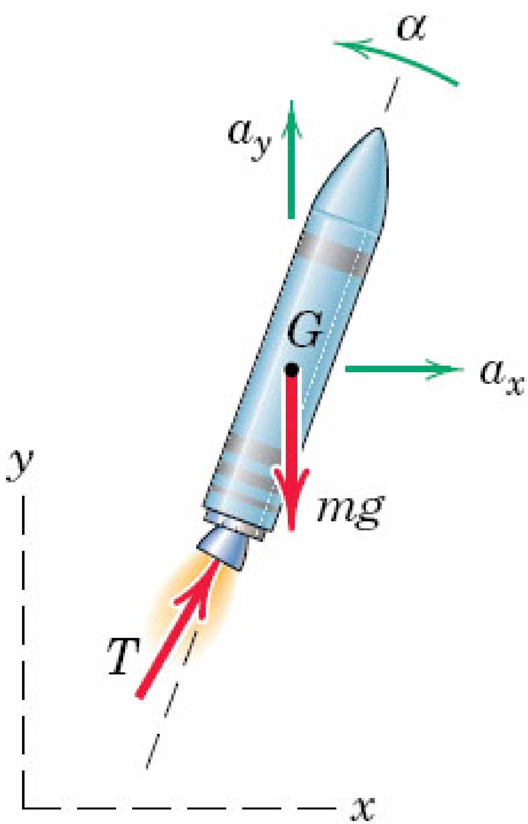
$$\sum \mathbf{M}_O = I_O \boldsymbol{\alpha}$$

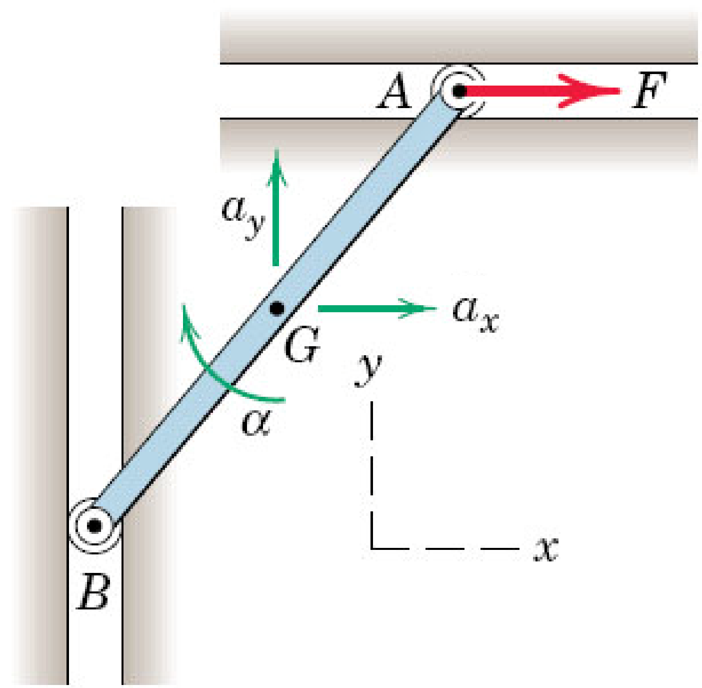
Plane Motion Types

- Translation
- Fixed-axis rotation
- General plane motion



Unconstrained and Constrained Motion



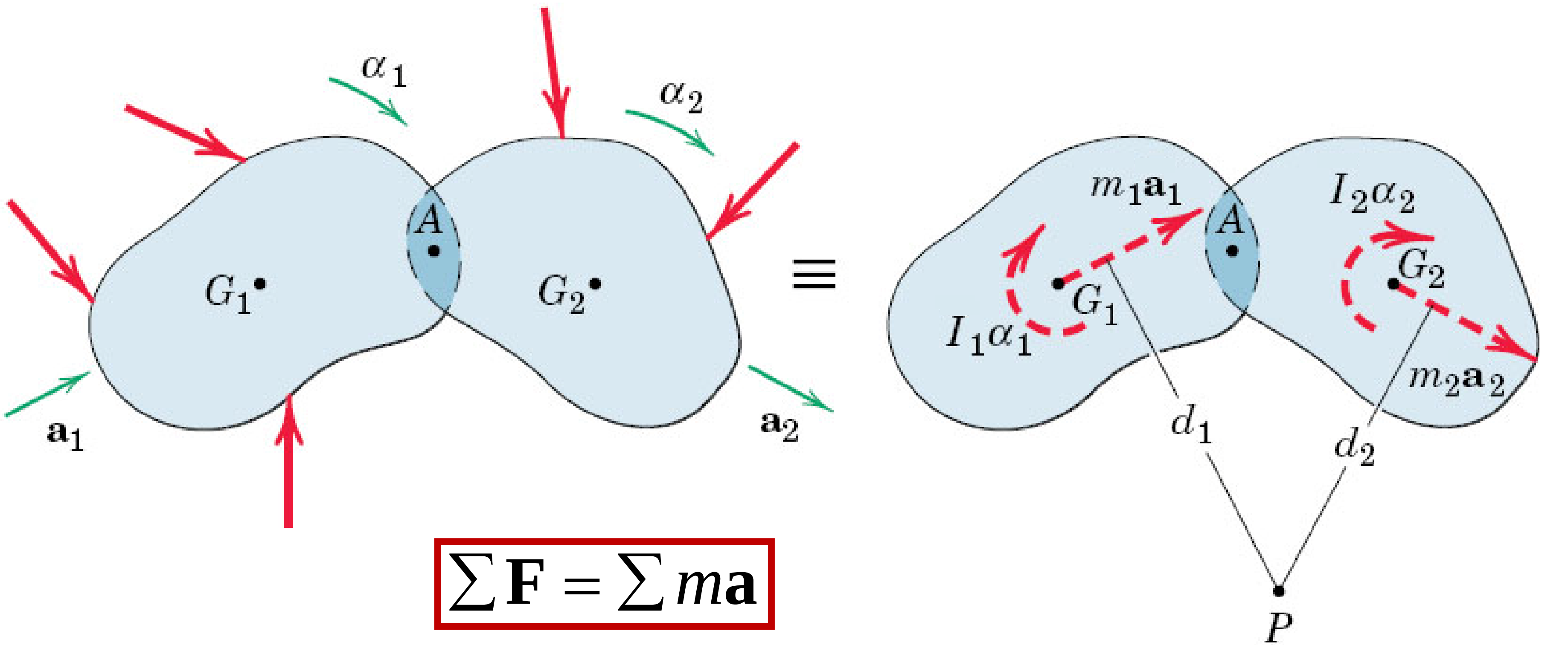


Unconstrained: a_x, a_y, and α may be determined independently from force/moment equations

Constrained: a_x, a_y, and α kinematic relationships may be determined and then combined with force/moment equations

Systems of Interconnected Bodies

free-body diagram *kinetic diagram*



$$\sum \mathbf{F} = \sum m\mathbf{a}$$

$$\sum M_P = \sum I_G \alpha + \sum mad$$

Outline for Today

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Step-by-Step Solution Process

1. ***Kinematics***
   - Identify type of ***motion***
   - Solve for ***linear*** and ***angular accelerations***
2. ***Diagram***
   - Assign ***inertial coordinate system***
   - Draw complete ***free-body diagram***
   - Draw ***kinetic diagram*** to clarify equations
3. ***Equations of motion***
   - Apply ***2 linear*** and ***1 angular equations***
   - Maintain ***consistent sense***
   - Solve for no more than 5 scalar unknowns (***3 scalar equations of motion*** and ***2 scalar relations*** from the ***relative-acceleration equation***)

Outline for Today

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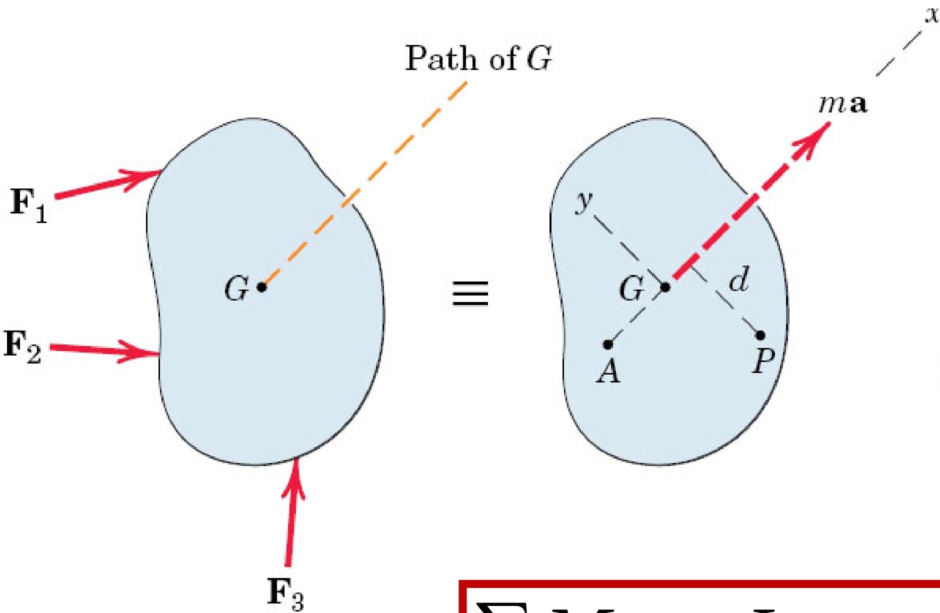
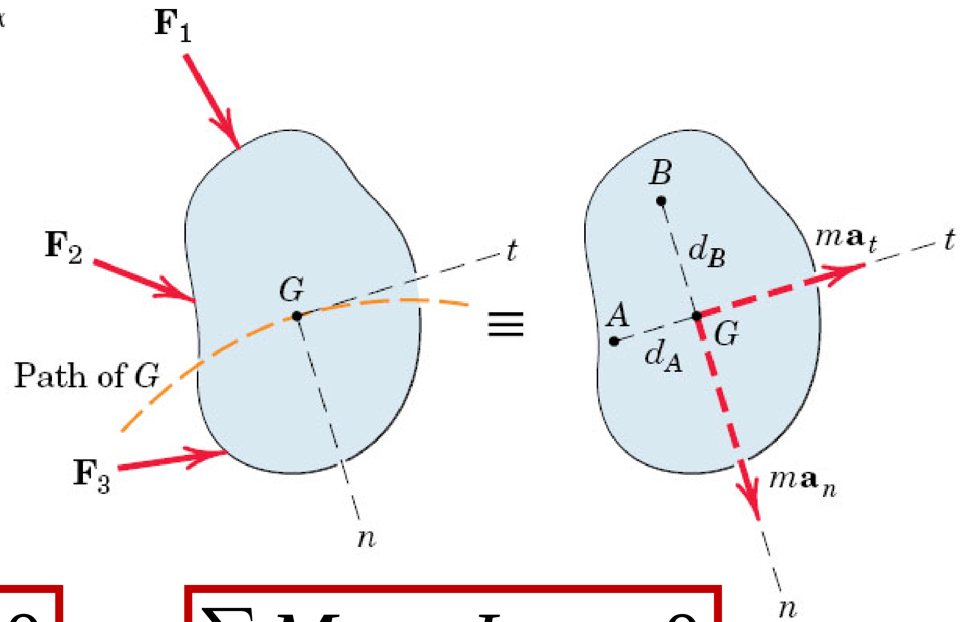
Rigid-Body Translation

rectilinear



curvilinear



$$\sum \mathbf{F} = m\mathbf{a}$$

$$\alpha = 0$$

$$\omega = 0$$

$$\sum M_G = I_G \alpha = 0$$

$$\sum M_P = mad$$

$$\sum M_A = 0$$

$$\sum M_G = I_G \alpha = 0$$

$$\sum M_A = ma_n d_A$$

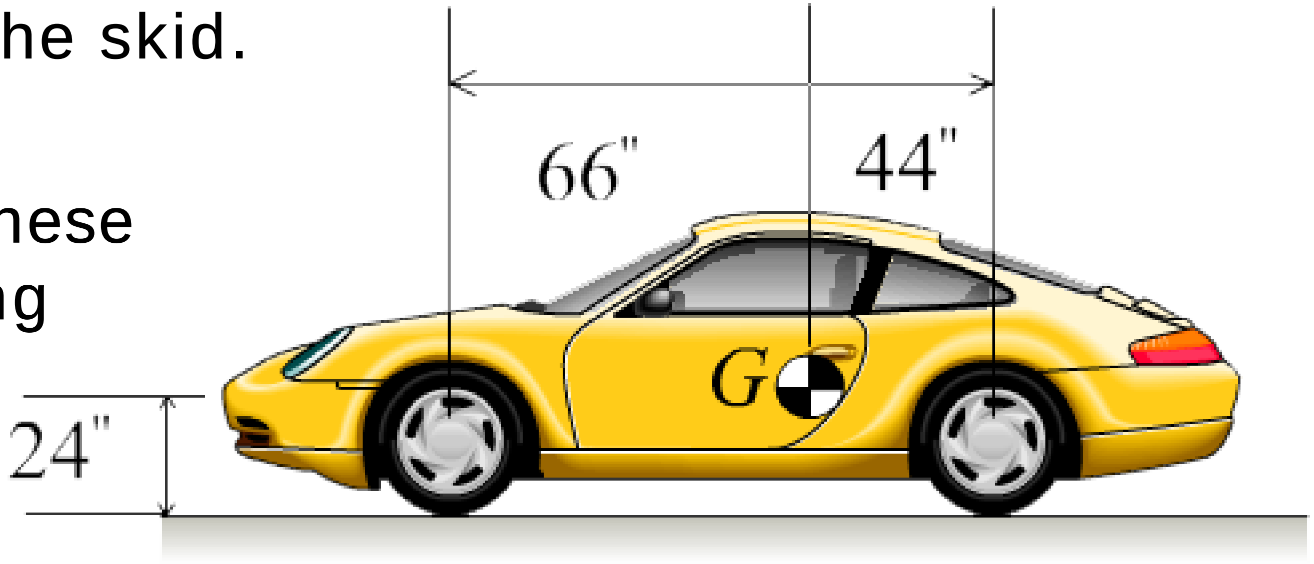
$$\sum M_B = ma_t d_B$$

Rigid-Body Translation: Exercise

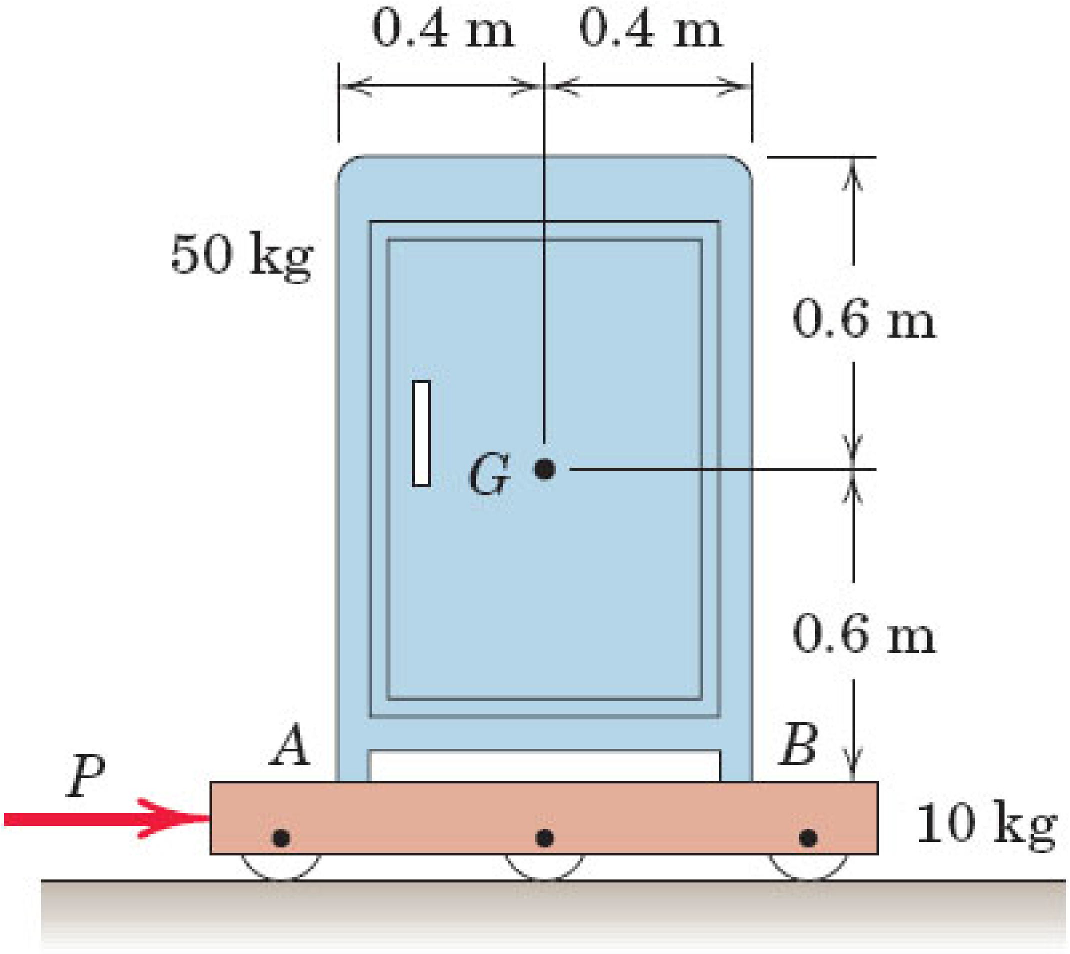
The ***3200-lb*** rear-engine car is traveling forward at a constant velocity when the brakes lock up all four wheels. The coefficient of kinetic friction is 0.8 between the tire and the road.

Determine the ***normal force*** under each tire just before the skid.

Determine these ***forces*** during the skid.



Rigid-Body Translation: Another Exercise



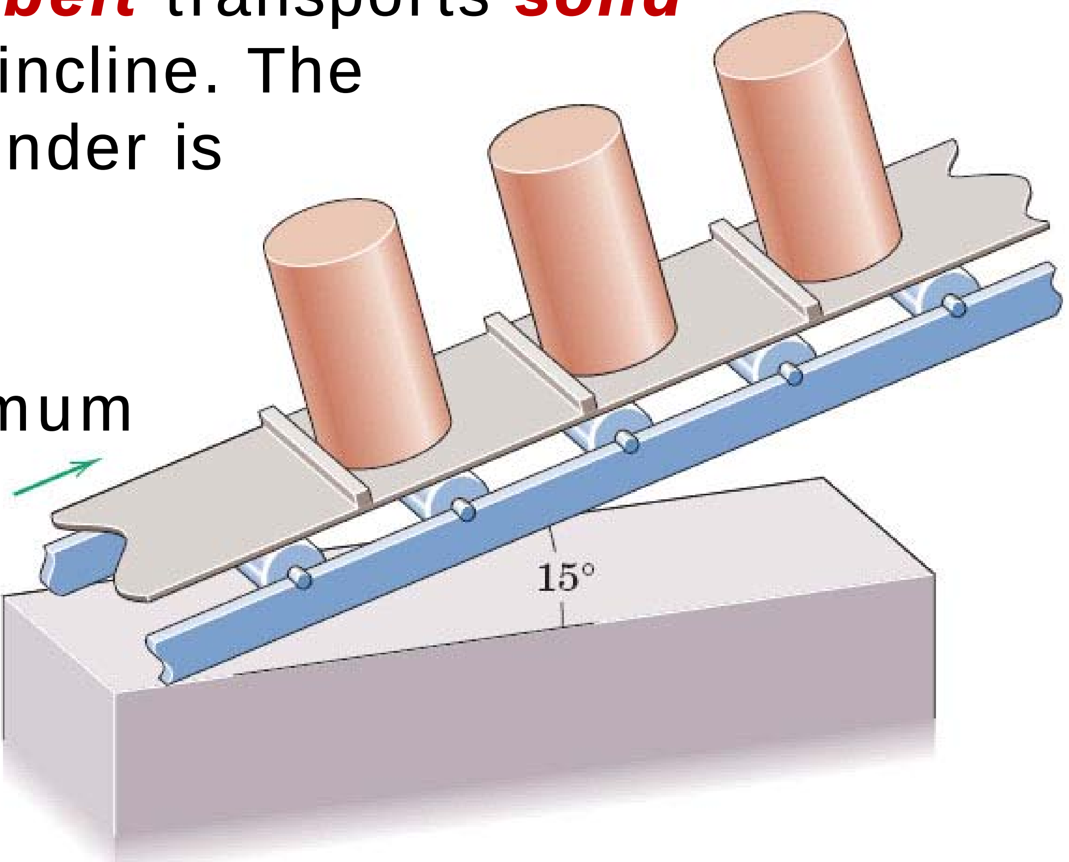
Determine the value of the ***force P*** which would cause the cabinet to begin to tip.

What ***coefficient of static friction*** is necessary to ensure tipping occurs without slipping?

Rigid-Body Translation: Yet Another Exercise

A cleated ***conveyor belt*** transports ***solid cylinders*** up a ***15º*** incline. The diameter of each cylinder is half its height.

Determine the maximum ***acceleration*** for the ***belt*** without tipping the ***cylinders*** as it starts.



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For Next Time…

- Continue Homework #8 due next ***Wednesday (10/19)***
- Read Chapter 6, Article 6/4