MECH230 - Fall 2024
Recommended Problems - Set 16

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November 11, 2024

Kinetics of Rigid Bodies A rigid body is subject to Euler's first law, the balance of linear momentum, and Euler's second law, the balance of angular momentum. The BoLM is written as

$$\mathbf{F} = m\mathbf{a}_C, \tag{1}$$

where the resultant force $\mathbf{F}$ acting on the rigid body is the sum of all forces acting on it. The BoAM has three equivalent forms

$$\mathbf{M}^O = \dot{\mathbf{H}}^O \quad \text{about a fixed point } O, \tag{2}$$

$$\mathbf{M}^C = \dot{\mathbf{H}}^C \quad \text{about the center of mass } C, \tag{3}$$

$$\mathbf{M}^P = \dot{\mathbf{H}}^P + (\mathbf{v}_P - \mathbf{v}_C) \times \mathbf{G} = \dot{\mathbf{H}}^C + (\mathbf{r}_C - \mathbf{r}_P) \times m\mathbf{a}_C \quad \text{about any material point } P \text{ on the body.} \tag{4}$$

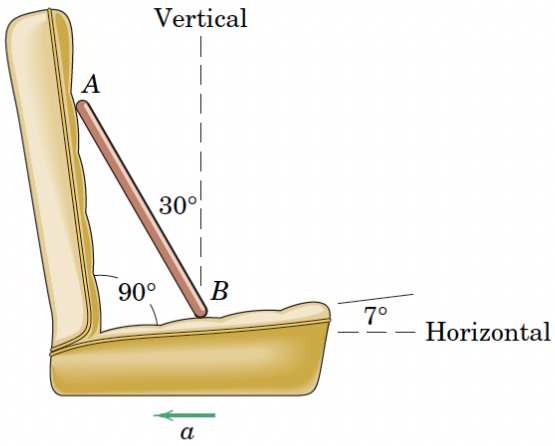
Consider a rigid body with K applied forces $\mathbf{F}_i$ at points with position vectors $\mathbf{r}_i$ and an applied couple $\mathbf{M}^e$, then the sum of moments about an arbitrary point P on the body is

$$\mathbf{M}^P = \sum_{i=1}^{K} (\mathbf{r}_i - \mathbf{r}_P) \times \mathbf{F}_i + \mathbf{M}_e. \tag{5}$$

These problems are taken from J. L. Meriam, L. G. Kraige, and J. N. Bolton (MKB), Engineering Mechanics: Dynamics, Ninth Edition, Wiley, New York, 2018.

1. [MKB 06-006]

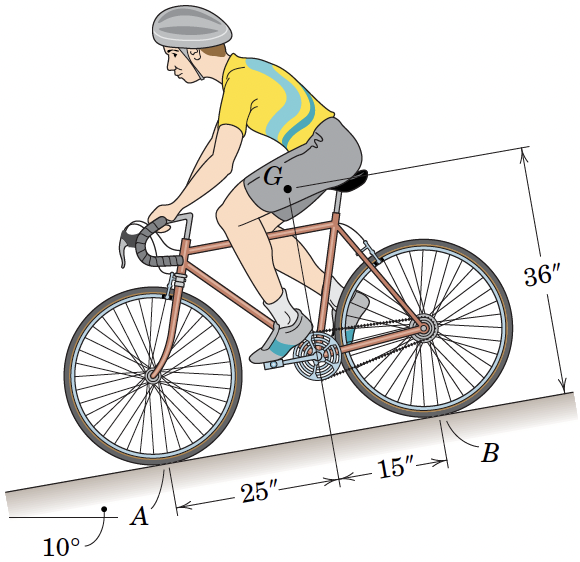
6/6 A uniform slender rod rests on a car seat as shown. Determine the deceleration a for which the rod will begin to tip forward. Assume that friction at B is sufficient to prevent slipping.



PROBLEM 6/6

2. [06-012]

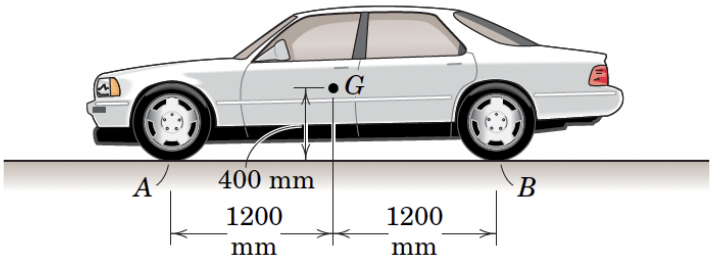
6/12 The bicyclist applies the brakes as he descends the 10° incline. What deceleration a would cause the dangerous condition of tipping about the front wheel A? The combined center of mass of the rider and bicycle is at G.



PROBLEM 6/12

3. [06-013]

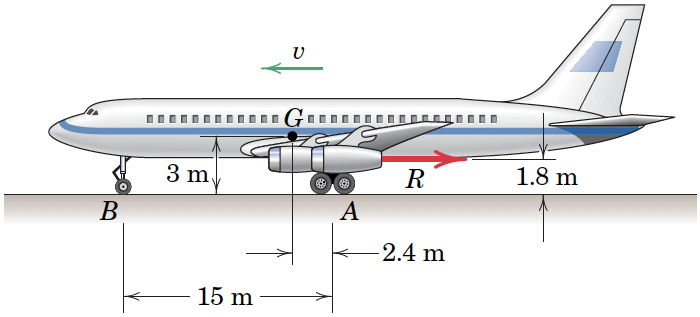
6/13 **SS** The 1650-kg car has its mass center at G. Calculate the normal forces N_A and N_B between the road and the front and rear pairs of wheels under conditions of maximum acceleration. The mass of the wheels is small compared with the total mass of the car. The coefficient of static friction between the road and the rear driving wheels is 0.80.



PROBLEM 6/13

4. [06-022]

6/22 A jet transport with a landing speed of 200 km/h reduces its speed to 60 km/h with a negative thrust R from its jet thrust reversers in a distance of 425 m along the runway with constant deceleration. The total mass of the aircraft is 140 Mg with mass center at G. Compute the reaction N under the nose wheel B toward the end of the braking interval and prior to the application of mechanical braking. At the lower speed, aerodynamic forces on the aircraft are small and may be neglected.



PROBLEM 6/22