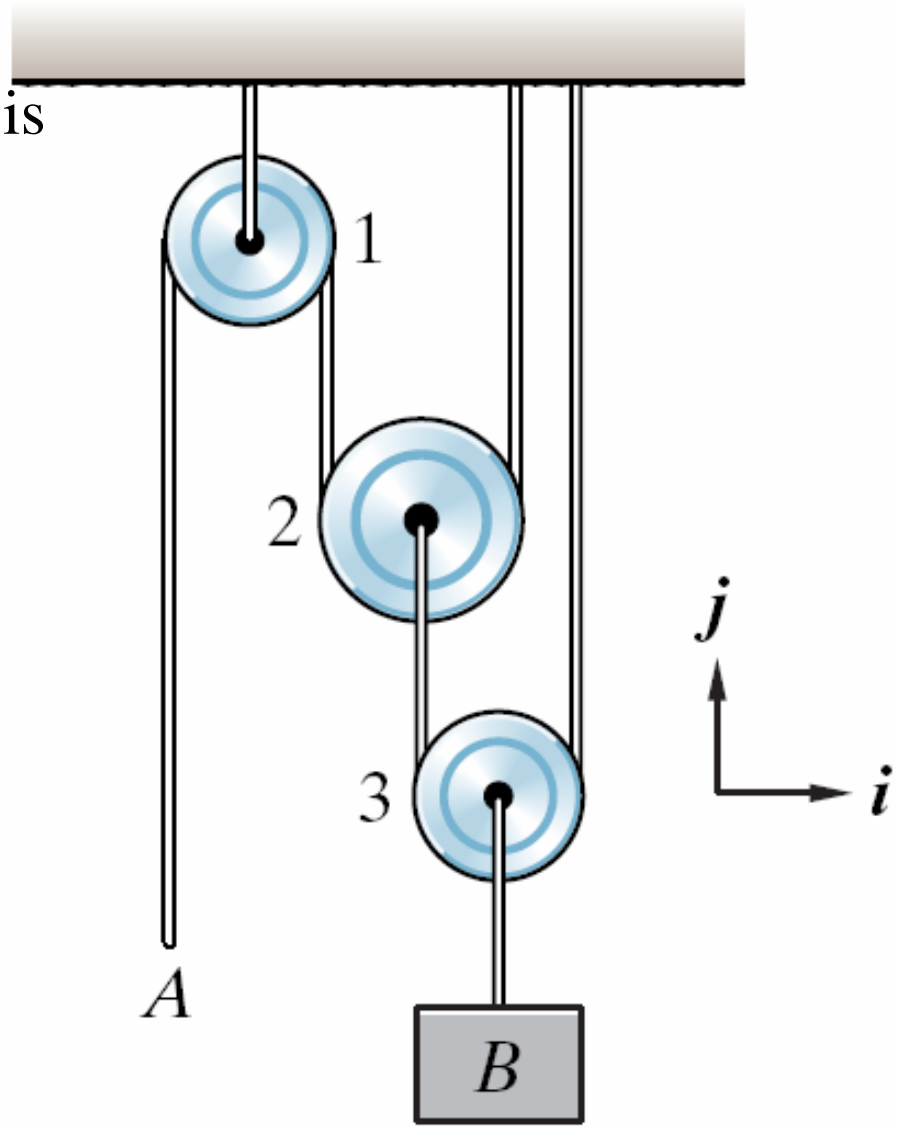
Example (from last lecture)

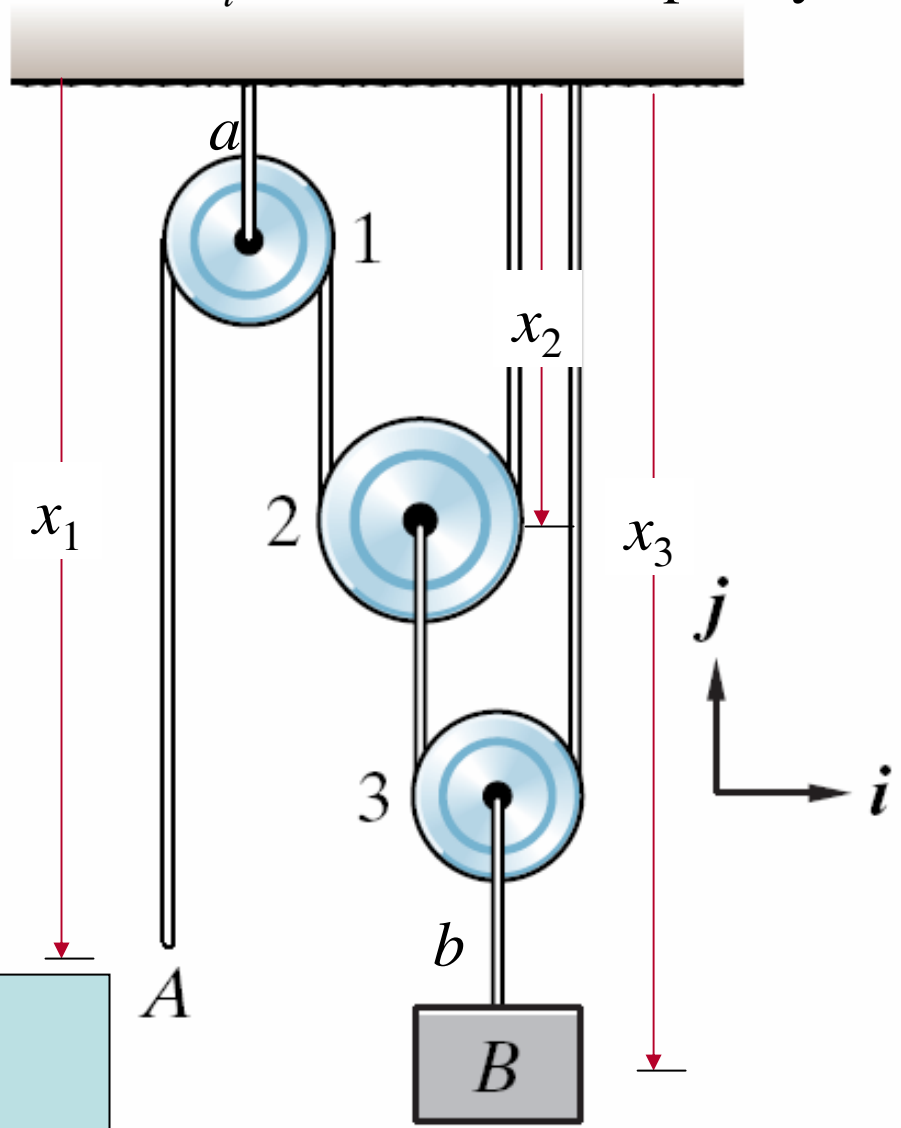
A is pulled down at 3 *m*/*s*. What is the motion of *B*?



Exercise 2.5.11 (p. 85)

KEY Identify (a) particles; (b) constraints.

Let r_i be the radius of pulley i.



There are 3 particles and 2 cables whose lengths cannot change!

$$(x_1 - a) + \pi r_1 + (x_2 - a) + \pi r_2 + x_2 = L_1$$

$$(x_3 - b - x_2) + \pi r_3 + (x_3 - b) = L_2$$

Differentiating these constraints, we obtain:

Discussion on linkages and mechanisms will resume on Wednesday!

Dynamics of Particles [TS, Chapter 3]

Three Keys

- Calculate acceleration and/or force
  - Cartesian coordinates
  - Polar coordinates
  - Path coordinates
- Free-Body Diagram (FBD) and Inertia Response Diagram (IRD)
- Force balance
  - Total (resultant force) = mass . Acceleration

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

    in the appropriate coordinate system

Summary: Transformations between unit vectors

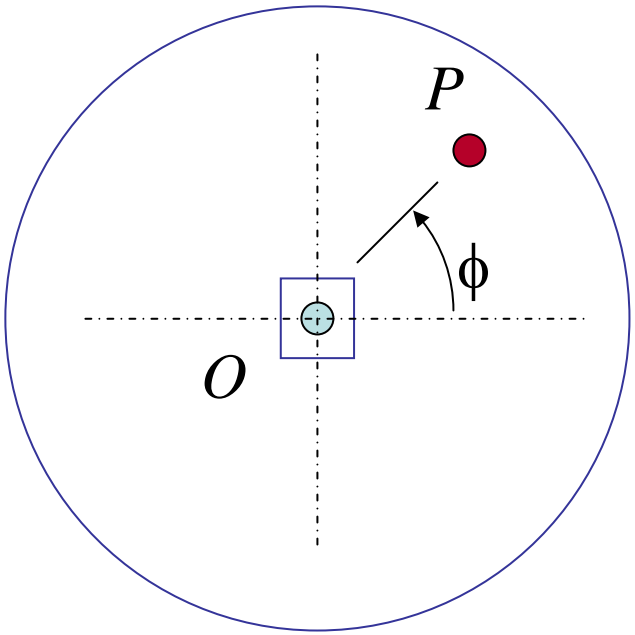
- Understanding the relationship between sets of unit vectors is very important
  - Visualize
  - Write down the dot products

	$\mathbf{e}_1$	$\mathbf{e}_2$	$\mathbf{e}_3$
i			
j			
k			

Three Steps

- Find the force and/or acceleration of the particle (in appropriate coordinate system)
  - You may have to use variables for unknown quantities
- Draw the Free-Body Diagram (FBD) and the Inertia-Response Diagram (IRD)
  - FBD must show all force vectors (*no components*) and the particle and *nothing else)*
  - IRD must show mass times acceleration vector (*no components!*) and the particle and *nothing else*
- Commit to a suitable coordinate system
  - Redraw FBD=IRD with components
  - Write force balance with components

Example 1



The carousel rotates about an axis perpendicular to the plane of this paper passing through *O* at a constant rate of 11.5 rotations per minute (1.2 rads/sec). Your friend (mass 50 kgs.) is walking radially outward (as seen by someone fixed to the carousel) with a speed of 2 mph (0.89 meters/second) at the point shown (OP = 5.5 *m*). What are the forces acting on your friend's foot?

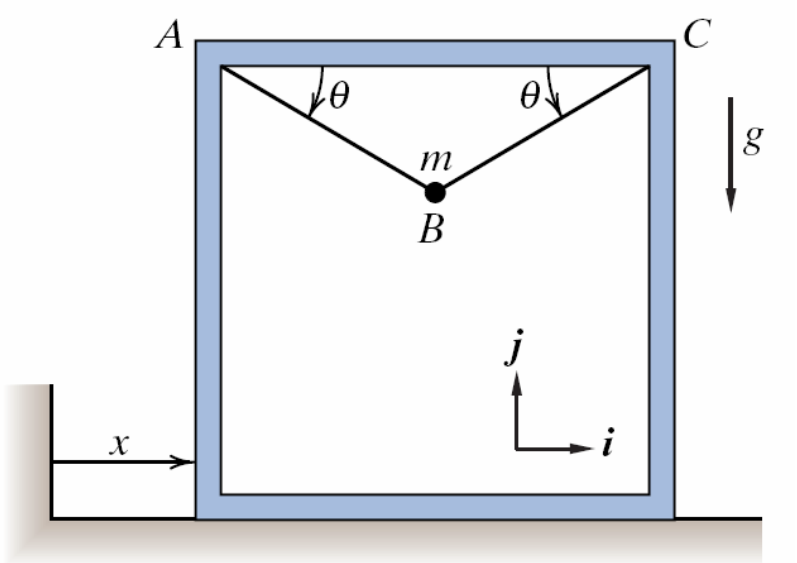
Ans

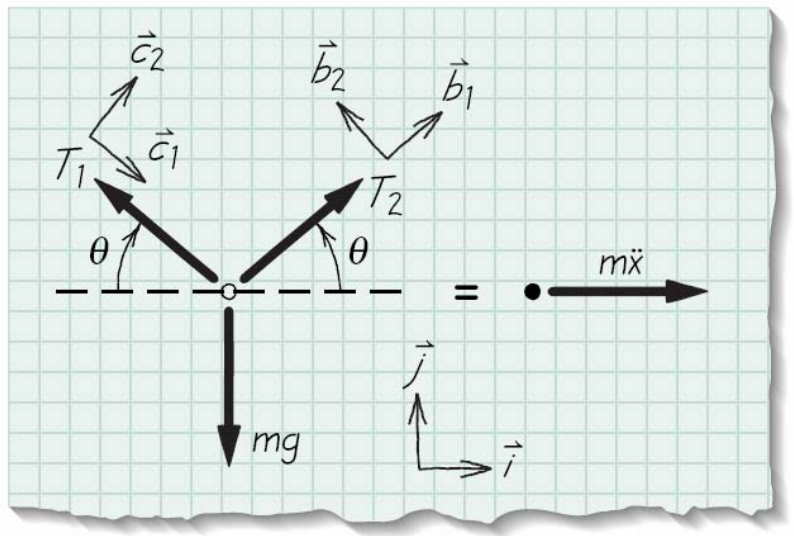
a_r= -7.98 m/sec^2

a_θ= 2.14 m/sec^2

- Find the acceleration and/or acceleration of the particle (in appropriate coordinate system)
- Draw the Free-Body Diagram (FBD) and the Inertia-Response Diagram (IRD)
- Commit to a suitable coordinate system
  - Redraw FBD=IRD with components
  - Write force balance with components

Example 2

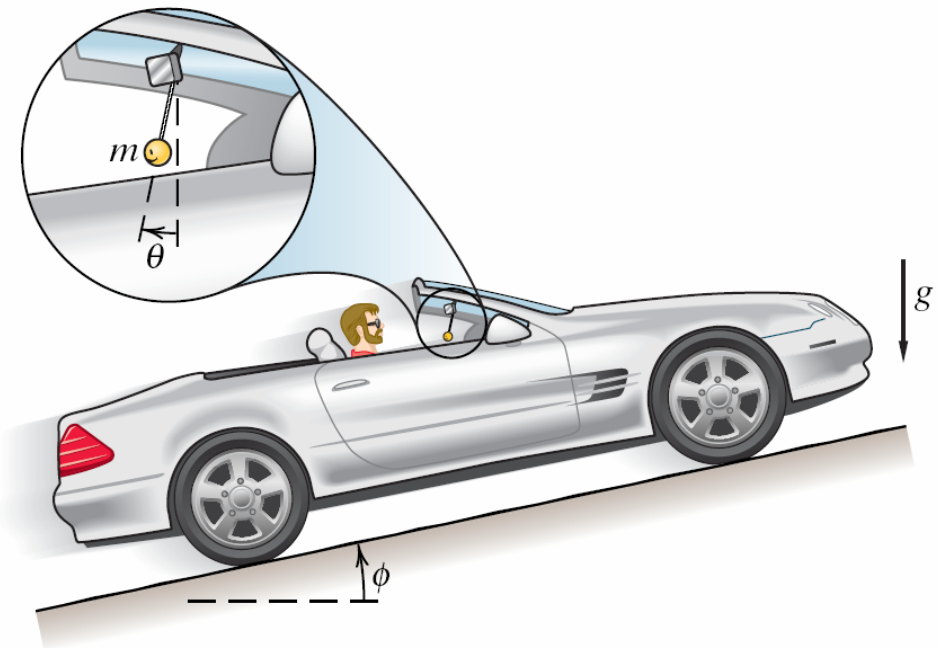


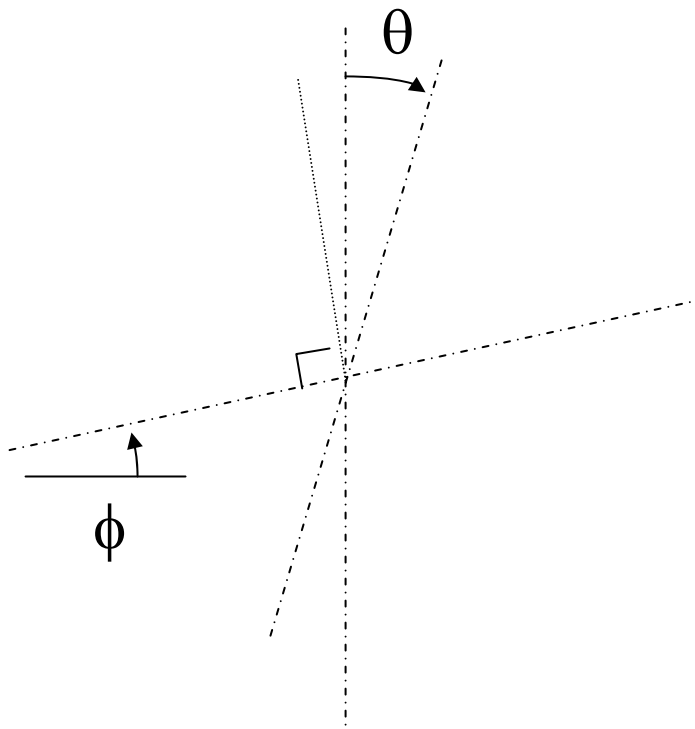


FBD IRD

Example 3

A car is climbing a hill and accelerating at 0.3 g. ϕ=10 deg. What is the steady-state value of θ?



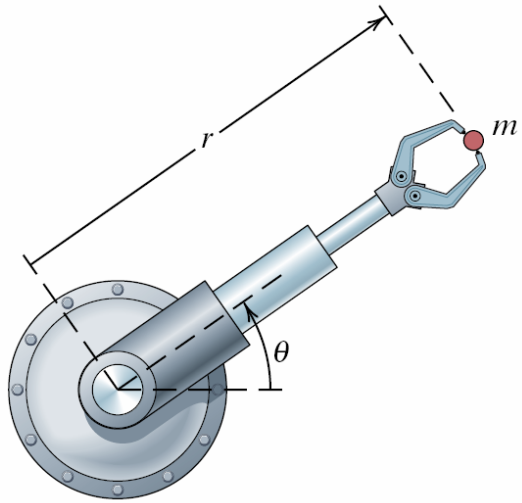


Example 3.6: Acceleration for a "weird" trajectory

Calculate the forces on the payload if the arm follows a path given by

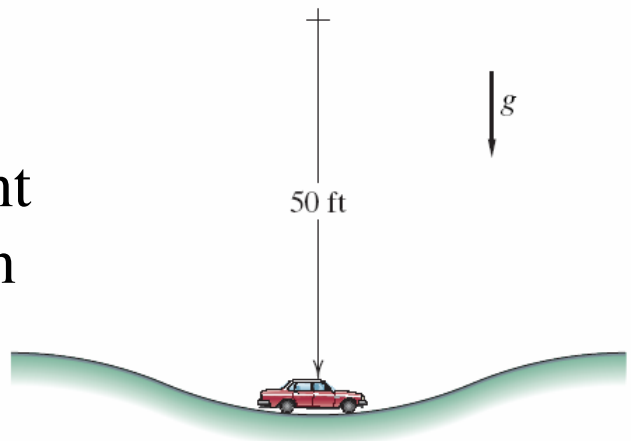
$$r(t) = a_1 + a_2 t + a_3 t^2$$

$$\theta(t) = b_1 t + b_2 t^2$$

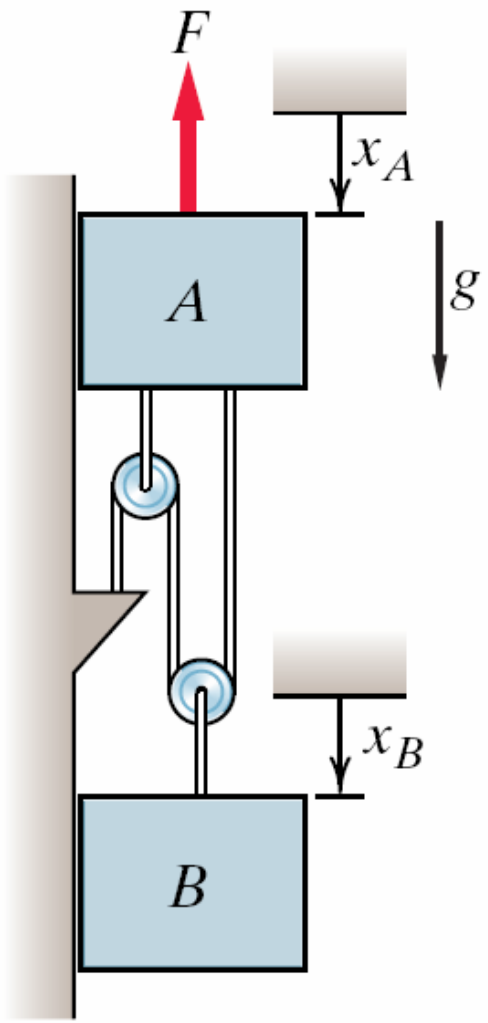


Problem 3.3.10

Speed = 20 mph; Weight = 3600 lbs
Radius of curvature = 50 ft.
Four springs, 800 lb/in spring constant
What is the compression/extension on each spring?



Problem 3.1.13: Two Masses



Given

$$m_A = 2.8kg, \quad m_B = 2.8kg$$

$$\ddot{x}_A = -7.13m/s^2$$

Equations of Motion:

$$m_A\ddot{x}_A = 3T + m_A g - F$$

$$m_B\ddot{x}_B = m_B g - 2T$$

Constraint Equation:

$3x_A - 2x_B = constant$