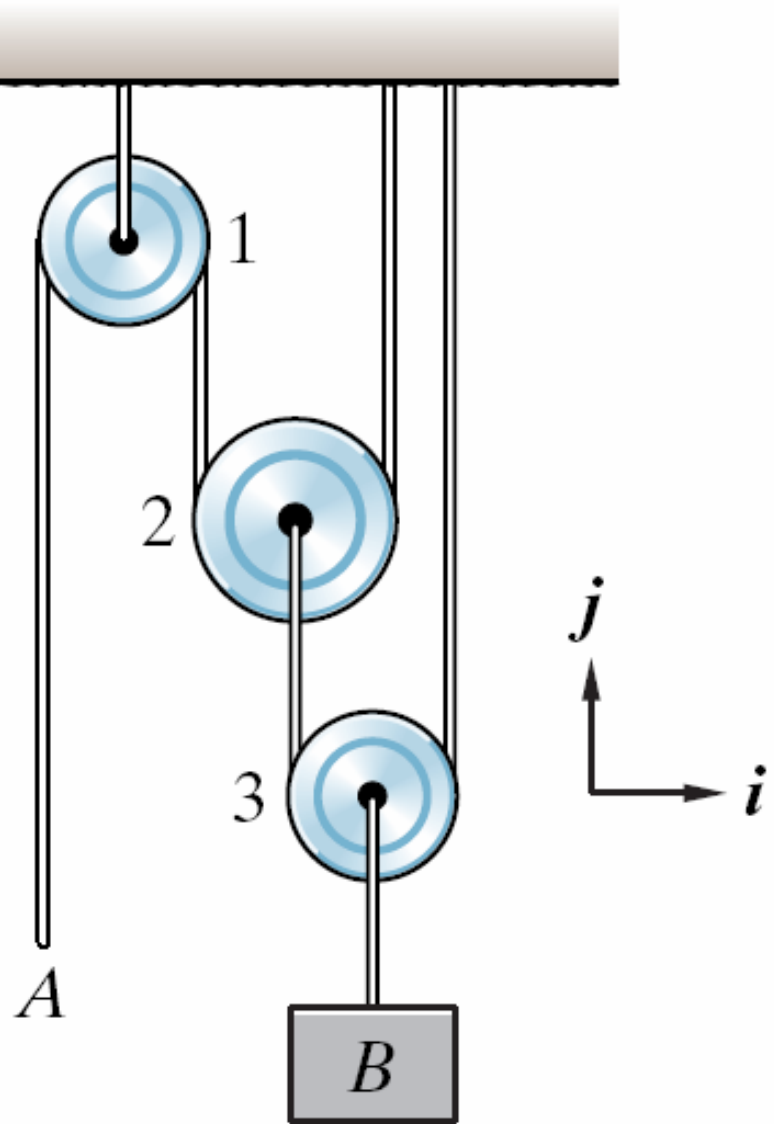


## Example (from last lecture)

$A$  is pulled down at  $3 \text{ m/s}$ . What is the motion of  $B$ ?



Exercise 2.5.11 (p. 85)

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

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

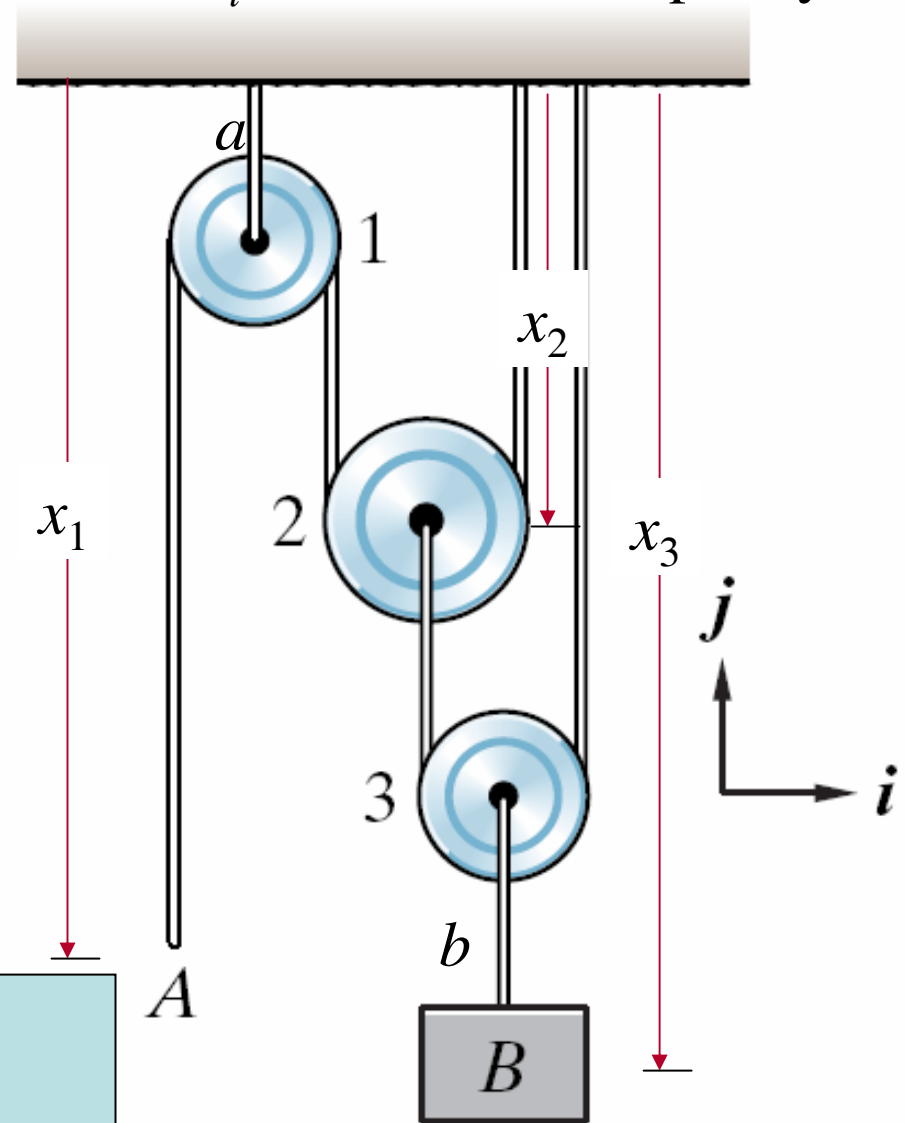
$$(x_1 - a) + \pi r_1 + (x_2 - a) + \pi r_2 + x_2 = L_1 \quad x_1$$

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

Differentiating these  
constraints, we obtain:



Let  $r_i$  be the radius of pulley  $i$ .



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

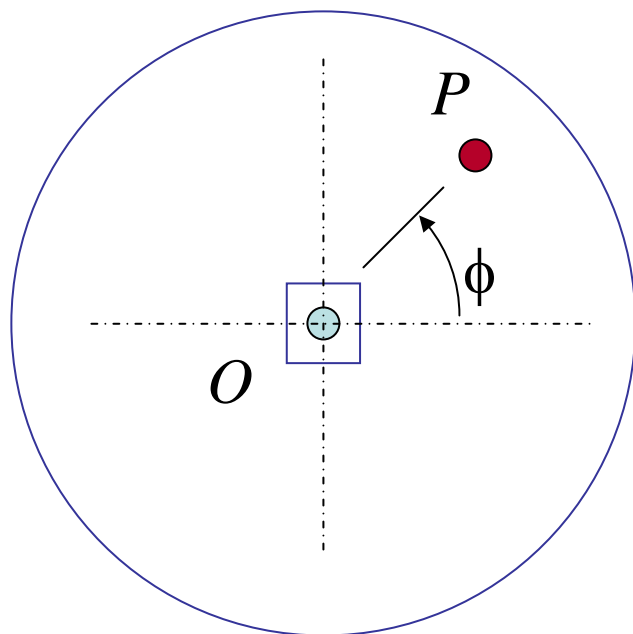
- Understanding the relationship between sets of unit vectors is very important
  - Visualize
  - Write down the dot products

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

## 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 ( $OP = 5.5 \text{ m}$ ). What are the forces acting on your friend's foot?

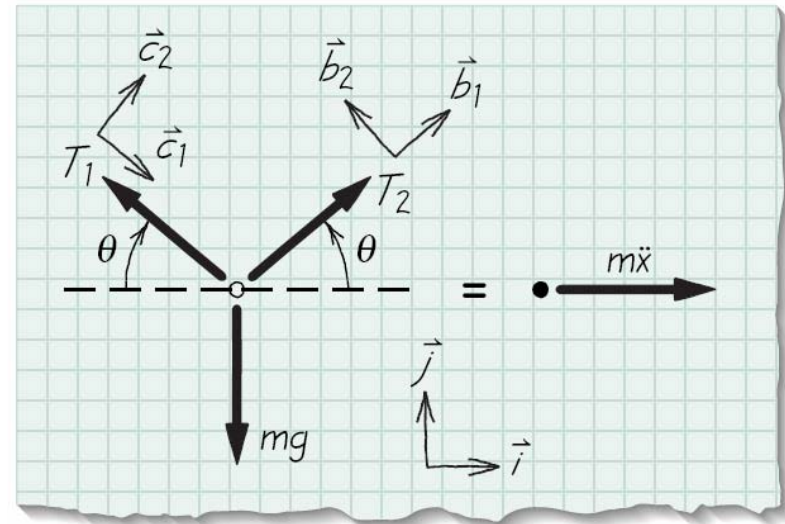
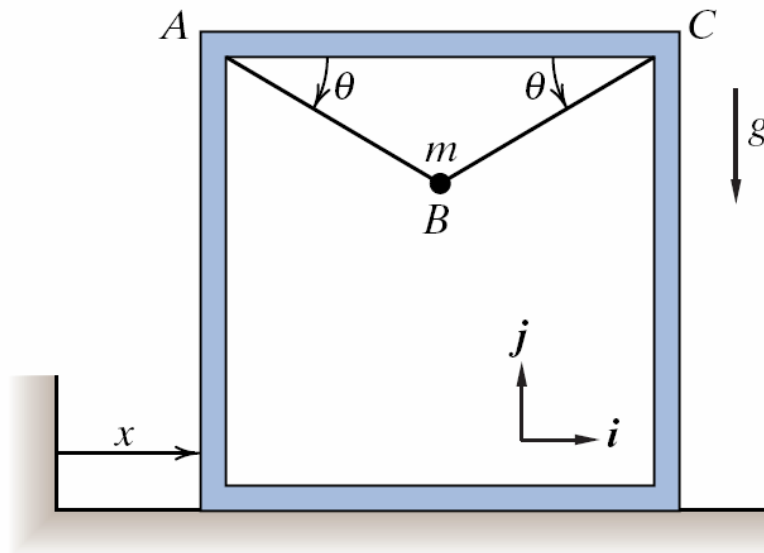
*Ans*

$$a_r = -7.98 \text{ m/sec}^2$$

$$a_\theta = 2.14 \text{ m/sec}^2$$

- ❑ 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

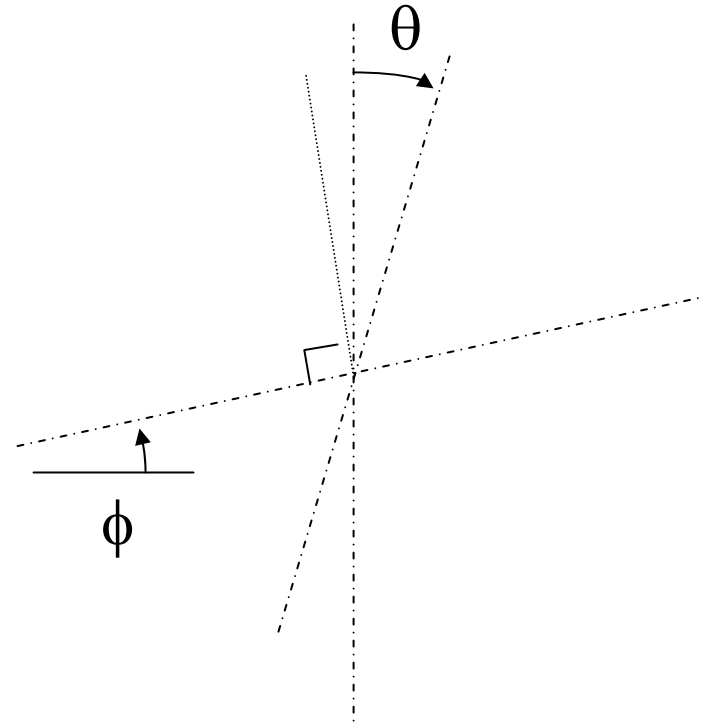
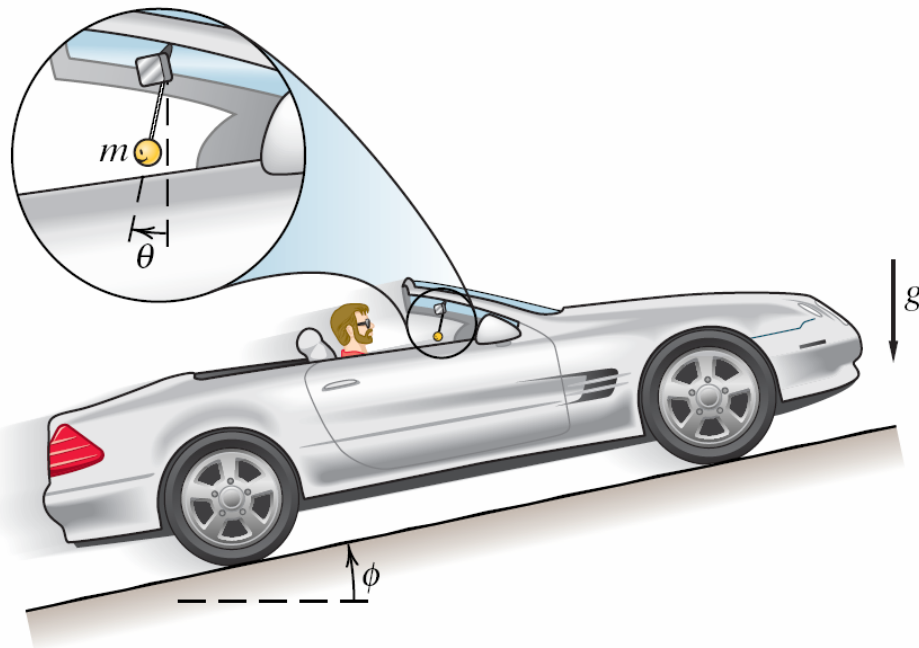


FBD

IRD

## Example 3

A car is climbing a hill and accelerating at  $0.3 g$ .  $\phi = 10$  deg.  
What is the steady-state value of  $\theta$ ?

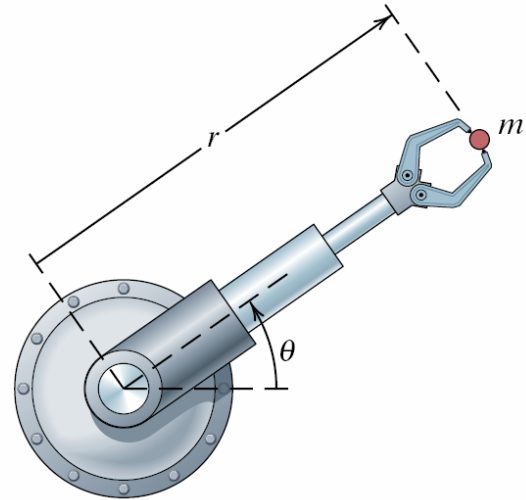


## Example 3.6: Acceleration for a “weird” trajectory

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

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

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



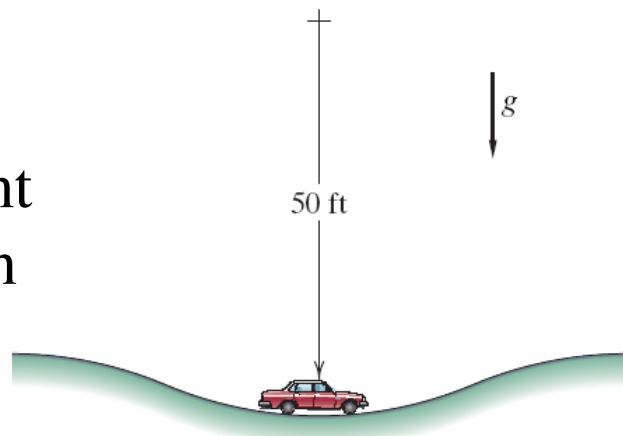
### Problem 3.3.10

Speed = 20 mph; Weight = 3600 lbs

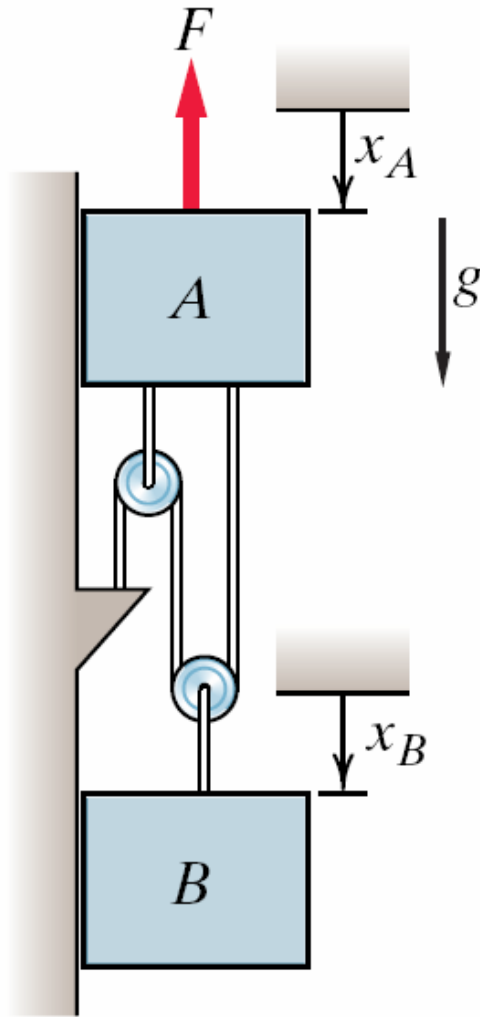
Radius of curvature = 50 ft.

Four springs, 800 lb/in spring constant

What is the compression/extension on each spring?



## Problem 3.1.13: Two Masses



Given

$$m_A = 2.8\text{kg}, \quad m_B = 2.8\text{kg}$$

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

Equations of Motion:

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

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

Constraint Equation:

$$3x_A - 2x_B = \text{constant}$$