STATIC EQUILIBRIUM OF A PARTICLE (2-D)

Learning Objectives

1). To draw a *free body diagram* (FBD) of an object that is modeled as a particle.

2). To evaluate the *forces* required for *static equilibrium* of an object that is modeled as a particle.

3). To do an *engineering estimate* of these quantities.

Force Classifications

External Forces: applied forces which are typically known or prescribed (e.g., forces due to cables, springs, gravity, etc.).

Reaction Forces: constraining forces at supports, intended to prevent motion (usually nonexistent unless system is externally loaded).

Free Body Diagram (FBD)

Free Body Diagram (*FBD*): a graphical sketch of the system showing a coordinate system, all external/reaction forces and moments, and key geometric dimensions.

Benefits:

1). Provides a *coordinate system* to establish a solution methodology.

2). Provides a *graphical display* of all forces/moments acting on the rigid body.

3). Provides a record of *geometric dimensions* needed for establishing moments of the forces.

Newton's First Law

Given *no net force*, a body at rest will remain at rest and a body moving at a constant velocity will continue to do so along a straight path ($\bar{R} = \sum \bar{F} = \bar{0}$).

Static Equilibrium

Vector Equation:

$$\bar{R} = \sum_{i=1}^{N} \bar{F}_i = \sum F_x \bar{i} + \sum F_y \bar{j}$$

Component Equations:

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

Problem Solving

1). Draw complete FBD.
2). Choose an xyz reference frame.
3). Evaluate the geometrical parameters.
4). Write equations of static equilibrium.
5). Count number of scalar equations and number of unknowns.
6). Solve equations of static equilibrium.

Note:

$F_{drag} = \frac{1}{2} \rho C_D S_A v^2$

Where ρ = density of air
C_D = Drag Coefficient
S_A = Frontal Surface Area
v = velocity

Newton's Laws of Motion

Newton's 1 st Law: An object at rest stays at rest and an object in motion stays in motion with the same speed and in the same direction unless acted upon by an unbalanced force

Newton's 2nd Law: The relationship between an object's mass *m*, its acceleration a, and the applied force *F* is *F = ma*. Acceleration and force are vectors (as indicated by their symbols being displayed in slant bold font); in this law the direction of the force vector is the same as the direction of the acceleration vector.

Newton's 3rd Law: For every action there is an equal and opposite reaction.

2-D Particle Equilibrium

Example 1

Given: Block D, whose weight is 100 lbs., is supported by cables AB and AC as shown and is in static equilibrium. Assume angle θ is measured at 50˚.

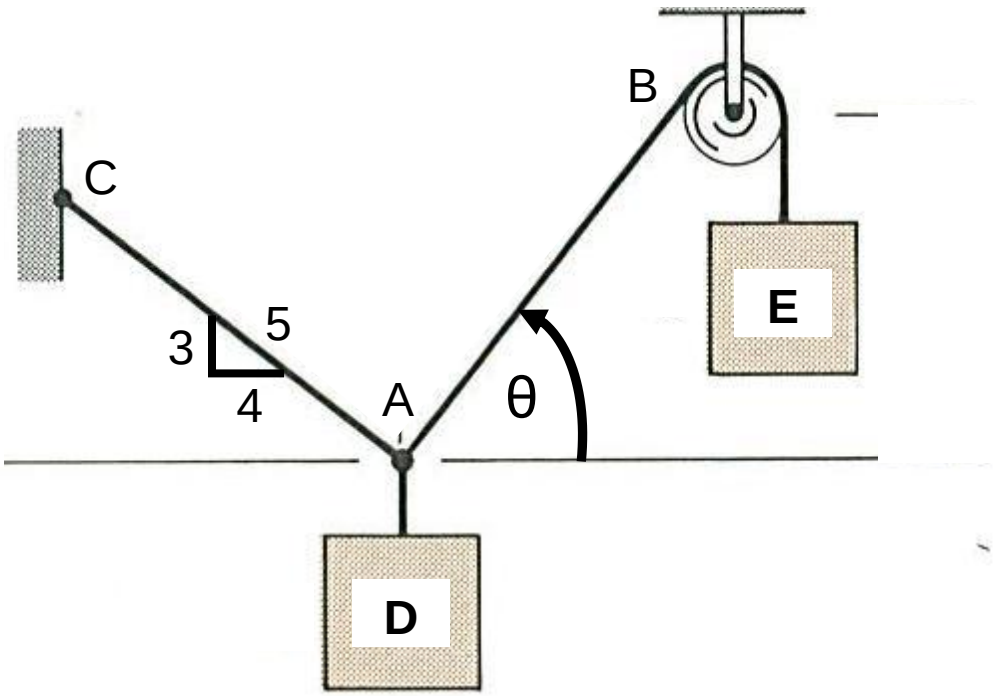
Find: Assuming pulley B can be treated as an ideal pulley,

a) Sketch a free body diagram of particle A.

b) Estimate the tension cables AB and AC. Which cable would you expect to carry the greatest tension and why?

c) Calculate the magnitude of the tensions in cables T_{AB} and T_{AC} and determine the weight of Block E.

d) If angle θ were increased from its initial value, what effect would this have on the magnitudes of T_{AB} and T_{AC}? (Increase, Decrease, Remain the same)



2-D Particle Equilibrium

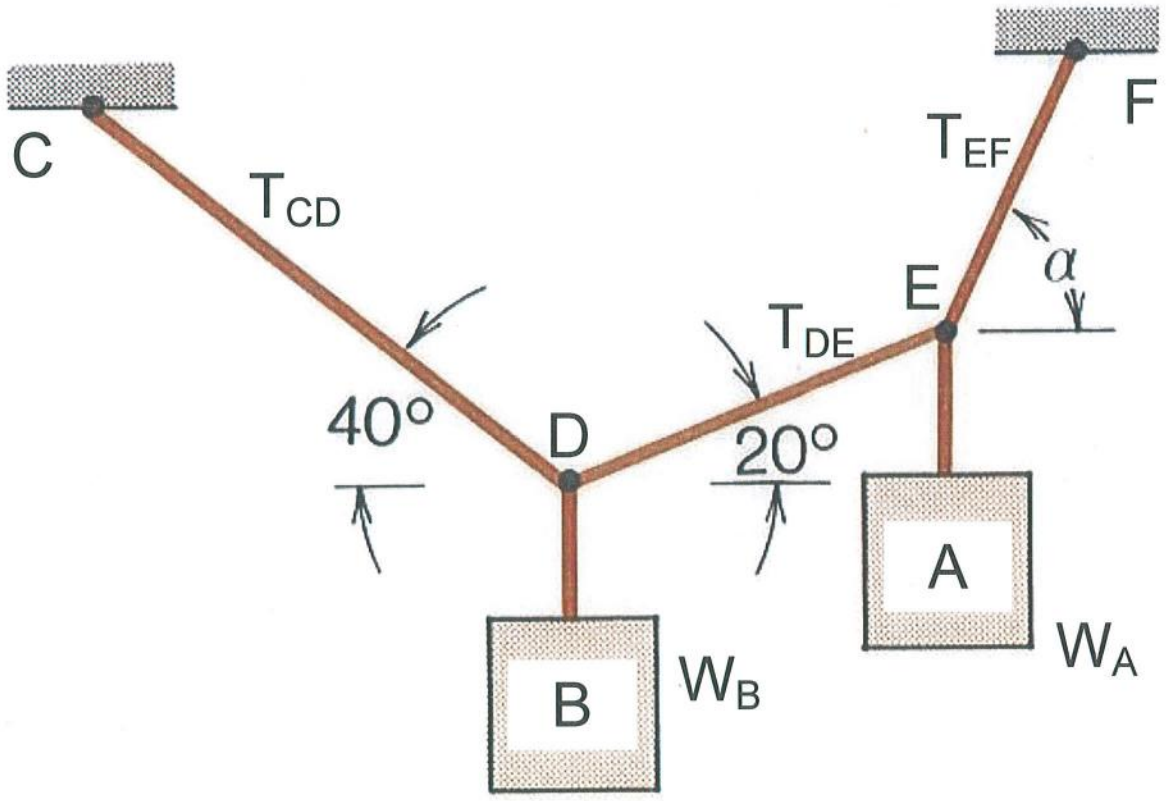
Example 2

Given: Block A and B each weigh 100 lbs. and are supported with the cable system shown. The cable system is in static equilibrium.

Find:

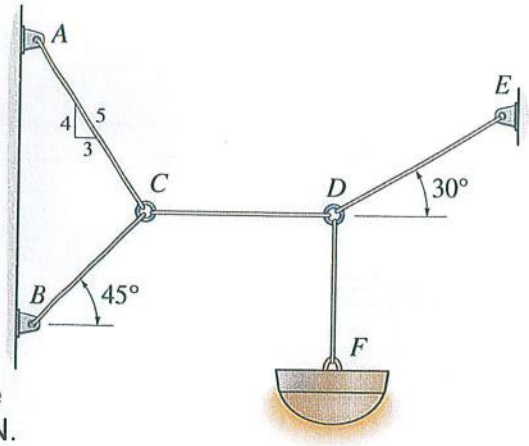
a) Determine tensions T_{CD} and T_{DE}.

b) Determine tension T_{EF} and angle $\propto$.



2-D Particle Equilibrium

Example 3



Given: A 200 N lamp is suspended in static equilibrium utilizing a series of cables as shown.

Find:

a) Based on your estimates, list each cable in the order of decreasing tension (i.e. highest tension first and lowest tension last).

b) Write the equations of static equilibrium and compute the tension in each cable given lamp (F) weighs 200N.

c) Determine heaviest lamp that can be supported with this cable configuration if the maximum tension in any cable cannot exceed 300 N.

Static Equilibrium of a Particle 2-D
Group Quiz

Group #: _____ Group Members: 1) _____
(Present Only)

Date: _____ Period: _____ 2) _____

3) _____

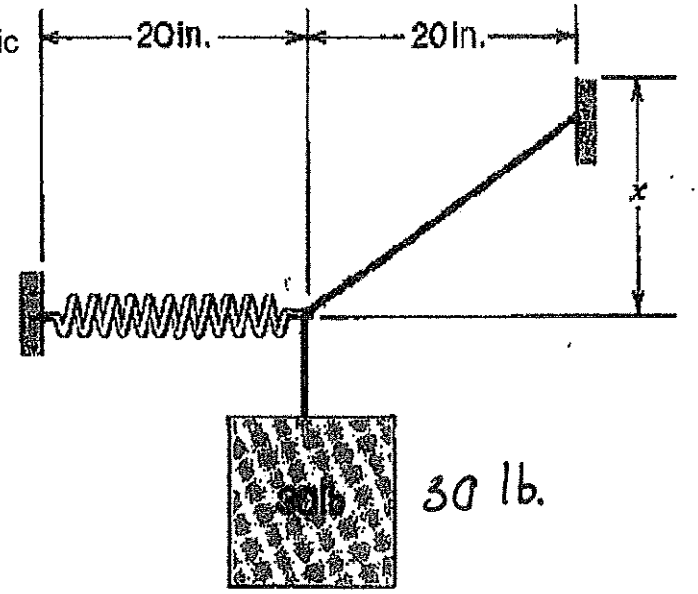
4) _____

Given: The spring has an unstretched length of 14 in. and a stiffness of 80 lb/ft.

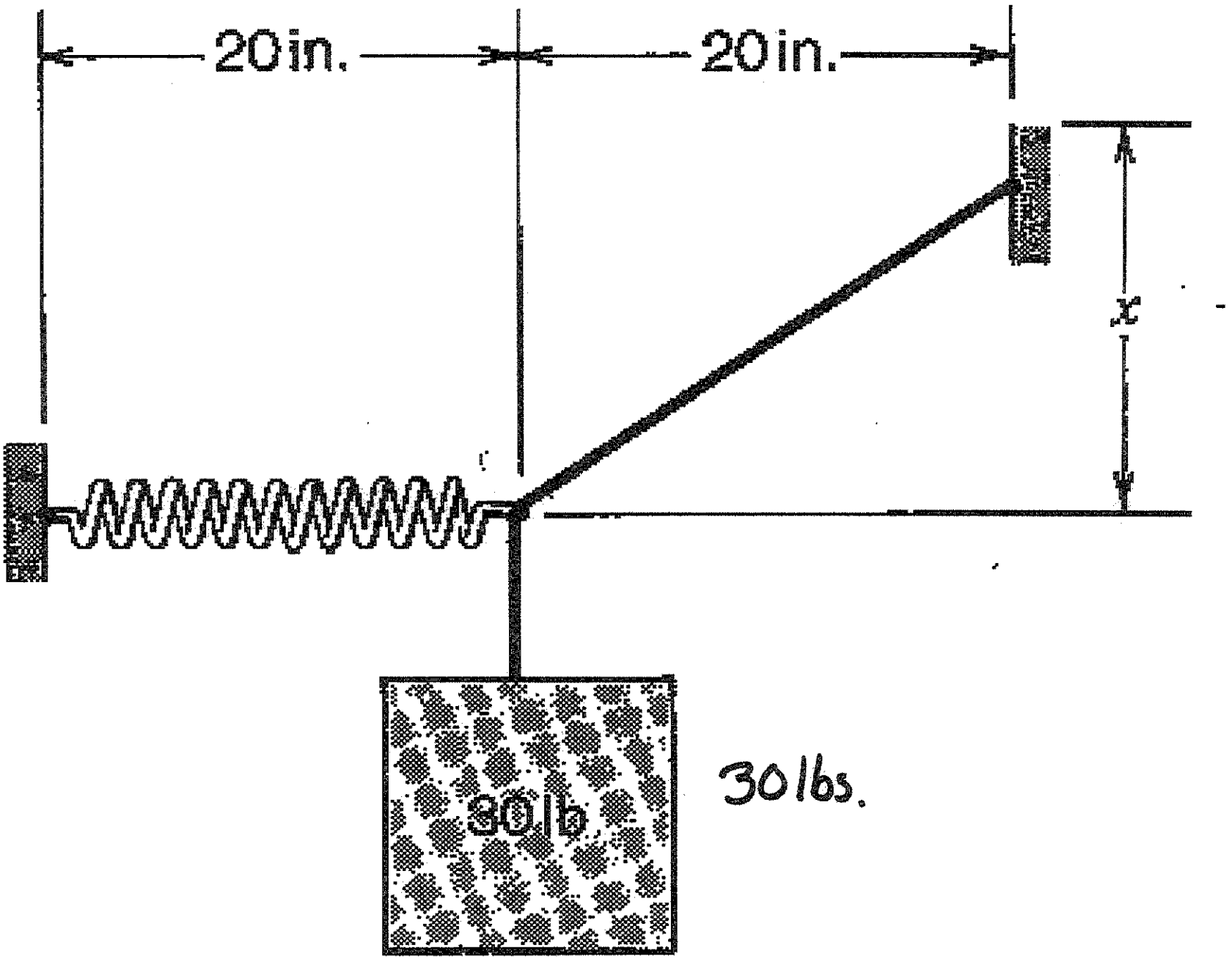
Find:

a) Determine the height x corresponding to static equilibrium in the position shown.

b) Determine the tension in the diagonal cable.



Solution:


20 in.
20 in.
x
30 lb
30 lbs.