

# Assignment 1-Solution

Due date: Friday September 24 (in classroom)

**Problem 1.** Use Newton's law of gravitation to determine the attracting force of Earth acting on an 80-kg man located:

- (a) on the surface of Earth at sea level,
- (b) in a spacecraft traveling in a circular orbit at 250 km above the earth's surface.
- (c) Determine the gravitational force exerted by the Sun on the same person when he is walking on the surface of Earth.

Express your final answer with the same number of significant figures used for the least accurate measurement (the weight of the person). Use the following data:

Gravitational constant =  $6.673 \times 10^{-11} \frac{m^3}{kg \cdot s^2}$ ; Earth's radius =  $6.37 \times 10^6$  m; Earth's mass =  $5.98 \times 10^{24}$  kg;

mean distance between the Sun and Earth =  $1.50 \times 10^{11}$  m; Sun's mass =  $1.989 \times 10^{30}$  kg. Express your answer both in newtons and pounds.

Solution (a)

$$F = 6.673 \times 10^{-11} \frac{m^3}{kg \cdot s^2} \frac{(5.98 \times 10^{24} kg)(80 kg)}{(6.37 \times 10^6 m)^2} = 786.7 \text{ N}$$

$$\text{Conversion to pounds: } F = 786.7 \text{ N} \left( \frac{1 \text{ lb}}{4.448 \text{ N}} \right) = 176.9 \text{ lb}$$

The weight of the person is the least accurate measurement, with only two significant figures. Therefore, the answer must be rounded to two significant figures:

F=790 N	Ans(a)
F=180 lb	Ans(a)

Solution (b)

$$F = 6.673 \times 10^{-11} \frac{m^3}{kg \cdot s^2} \frac{(5.98 \times 10^{24} kg)(80 kg)}{(6.37 \times 10^6 m + 2.5 \times 10^5 m)^2} = 728.4 \text{ N}$$

$$\text{Conversion to pounds: } F = 728.4 \text{ N} \left( \frac{1 \text{ lb}}{4.448 \text{ N}} \right) = 163.8 \text{ lb}$$

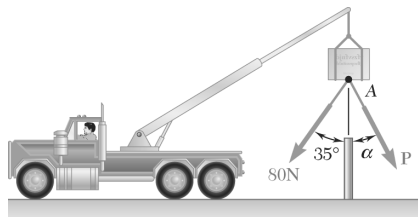
F=730 N	Ans(b)
F=160 lb	Ans(b)

Solution (c)

$$F = 6.673 \times 10^{-11} \frac{m^3}{kg \cdot s^2} \frac{(1.989 \times 10^{30} kg)(80 kg)}{(1.50 \times 10^{11} m)^2} = 0.47 \text{ N}$$

$$\text{Conversion to pounds: } F = 0.47 \text{ N} \left( \frac{1 \text{ lb}}{4.448 \text{ N}} \right) = 0.11 \text{ lb}$$

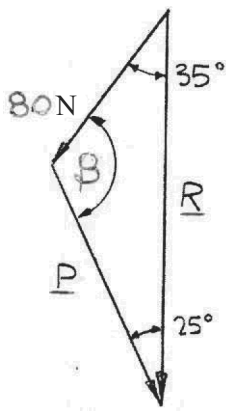
F=0 N	Ans(c)
F=0 lb	Ans(c)



### PROBLEM 2.11

To steady a sign as it is being lowered, two cables are attached to the sign at  $A$ . Using trigonometry and knowing that  $\alpha = 25^\circ$ , determine (a) the required magnitude of the force  $\mathbf{P}$  if the resultant  $\mathbf{R}$  of the two forces applied at  $A$  is to be vertical, (b) the corresponding magnitude of  $\mathbf{R}$ .

### SOLUTION



Using the triangle rule and the Law of Sines

Have:

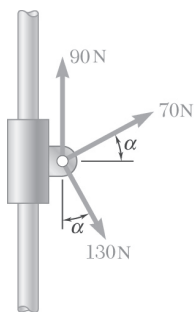
$$\begin{aligned}\beta &= 180^\circ - (35^\circ + 25^\circ) \\ &= 120^\circ\end{aligned}$$

Then:

$$\frac{P}{\sin 35^\circ} = \frac{R}{\sin 120^\circ} = \frac{80 \text{ N}}{\sin 25^\circ}$$

or (a)  $P = 108.6 \text{ N} \blacktriangleleft$

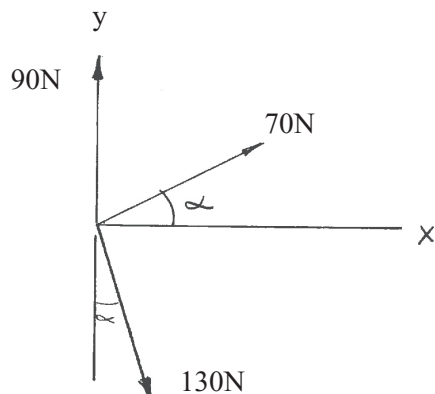
(b)  $R = 163.9 \text{ N} \blacktriangleleft$



### PROBLEM 2.36

A collar that can slide on a vertical rod is subjected to the three forces shown. Determine (a) the value of the angle  $\alpha$  for which the resultant of the three forces is horizontal, (b) the corresponding magnitude of the resultant.

### SOLUTION



(a) Since  $\mathbf{R}$  is to be horizontal,  $R_y = 0$

Then,  $R_y = \Sigma F_y = 0$

$$90 \text{ N} + (70 \text{ N}) \sin \alpha - (130 \text{ N}) \cos \alpha = 0$$

$$(13) \cos \alpha = (7) \sin \alpha + 9$$

$$13\sqrt{1 - \sin^2 \alpha} = (7) \sin \alpha + 9$$

$$\text{Squaring both sides: } 169(1 - \sin^2 \alpha) = (49) \sin^2 \alpha + (126) \sin \alpha + 81$$

$$(218) \sin^2 \alpha + (126) \sin \alpha - 88 = 0$$

Solving by quadratic formula:  $\sin \alpha = 0.40899$

$$\text{or } \alpha = 24.1^\circ \blacktriangleleft$$

(b) Since  $\mathbf{R}$  is horizontal,  $\mathbf{R} = R_x$

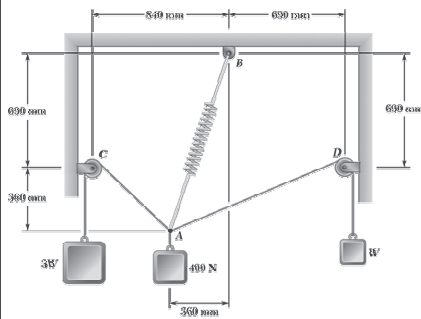
Then,  $\mathbf{R} = R_x = \Sigma F_x$

$$\Sigma F_x = (70) \cos 24.142^\circ + (130) \sin 24.142^\circ$$

$$\text{or } R = 117.0 \text{ N } \blacktriangleleft$$



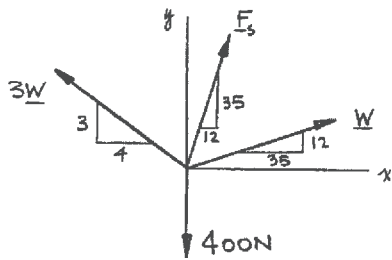
### PROBLEM 2.57



A load of weight 400 N is suspended from a spring and two cords that are attached to blocks of weights  $3W$  and  $W$  as shown. Knowing that the constant of the spring is 800 N/m, determine (a) the value of  $W$ , (b) the unstretched length of the spring.

### SOLUTION

Free-Body Diagram At A:



First note from geometry:

The sides of the triangle with hypotenuse  $AD$  are in the ratio 12:35:37.

The sides of the triangle with hypotenuse  $AC$  are in the ratio 3:4:5.

The sides of the triangle with hypotenuse  $AB$  are also in the ratio 12:35:37.

Then:

$$\rightarrow \Sigma F_x = 0: \quad -\frac{4}{5}(3W) + \frac{35}{37}(W) + \frac{12}{37}F_s = 0$$

or

$$F_s = 4.4833W$$

and

$$+\uparrow \Sigma F_y = 0: \quad \frac{3}{5}(3W) + \frac{12}{37}(W) + \frac{35}{37}F_s - 400 \text{ N} = 0$$

Then:

$$\frac{3}{5}(3W) + \frac{12}{37}(W) + \frac{35}{37}(4.4833W) - 400 \text{ N} = 0$$

or

$$W = 62.841 \text{ N}$$

and

$$F_s = 281.74 \text{ N}$$

or

(a)  $W = 62.8 \text{ N} \blacktriangleleft$



### PROBLEM 2.57 CONTINUED

(b) Have spring force

$$F_s = k(L_{AB} - L_O)$$

Where

$$F_{AB} = k_{AB}(L_{AB} - L_O)$$

and

$$L_{AB} = \sqrt{(0.360 \text{ m})^2 + (1.050 \text{ m})^2} = 1.110 \text{ m}$$

So:

$$281.74 \text{ N} = 800 \text{ N/m}(1.110 - L_O)\text{m}$$

$$\text{or } L_O = 758 \text{ mm} \blacktriangleleft$$