Homework #6

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Problem 1

Two forces $\vec{F_1} = 1.00\hat{i} + 2.00\hat{j}$ N and $\vec{F_2}$ which is 4.00 N directed at 37°, measured from the positive x-axis, act on a 200-g particle. What is its acceleration?

Solution

$$\vec{F_1} = 1.00\hat{i} + 2.00\hat{j} \text{ N}$$

$$\begin{aligned}\vec{F_2} &= (4.00\text{N}) * (\cos(37°)\hat{i} + \sin(37°))\hat{j} \\ &= (4.00\text{N}) * (\cos(37°))\hat{i} + (4.00\text{N}) * (\sin(37°))\hat{j} \\ &= (4.00\text{N}) * 0.7986\hat{i} + (4.00\text{N}) * 0.6018\hat{j} \\ &= 3.1945\hat{i} + 2.4073\hat{j} \text{ N}\end{aligned}$$

$$\vec{F_{net}} = \vec{F_1} + \vec{F_2} = (1.00\hat{i} + 2.00\hat{j} \text{ N}) + (3.1945\hat{i} + 2.4073\hat{j} \text{ N}) = 4.1945\hat{i} + 4.4073\hat{j} \text{ N}$$

$$\vec{a} = \frac{\vec{F_{net}}}{m} = \frac{4.1945\hat{i} + 4.4073\hat{j} \text{ N}}{0.2\text{kg}} = \boxed{20.973\hat{i} + 22.0363\hat{j} \text{ m/s}^2}$$

Problem 2

A Saturn V rocket has a mass of 2.70×10^6 kg and a thrust of 3.30×10^7 N. What is its initial vertical acceleration?

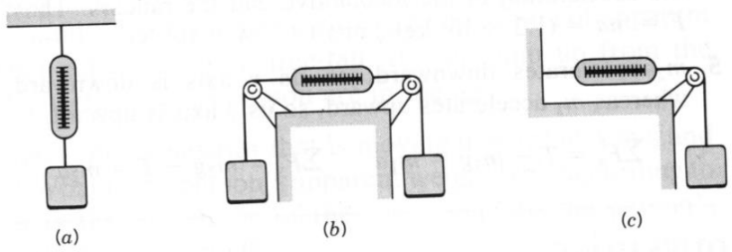
Solution

All this assuming that initially all thrust is directed vertically.

$$\vec{a} = \frac{\vec{F_{net}}}{m} = \frac{3.30 \times 10^7}{2.70 \times 10^6}\text{m/s}^2 = \boxed{12.22\text{m/s}^2}$$

Problem 3

What is the reading on the spring scale for each of the situations depicted in the figure below? Each of the blocks has a mass of 5.00 kg.



Solution

Situation (a)

There is only one force acting on the block, a downward force of gravity. As such, we can use the formula for the gravitational force here.

$$F_g = m * g = 5.00\text{kg} * 9.81\text{m/s}^2 = \boxed{49.05\text{N}}$$

Situation (b)

There are two forces acting on the spring scale, one on each side. The two are both from gravitatonal force on blocks of equal mass. We can use the formula for gravtatonal force again.

$$2 * F_g = 2 * m * g = 2 * 5.00\text{kg} * 9.81\text{m/s}^2 = 10.00\text{kg} * 9.81\text{m/s}^2 = \boxed{98.1\text{N}}$$

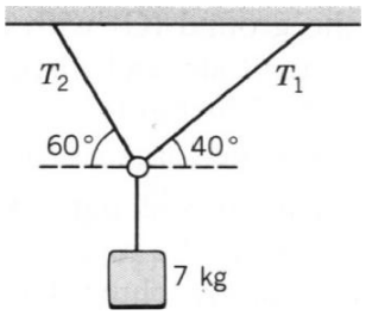
Situation (c)

There is only one force acting on the block, a downward force of gravity, which pulls the spring scale from one side. As such, we can use the formula for the gravitational force here.

$$F_g = m * g = 5.00\text{kg} * 9.81\text{m/s}^2 = \boxed{49.05\text{N}}$$

Problem 4

A 7.00-kg block is suspended with two ropes, as shown in the figure. Find the tension in each rope.



Solution

Since the block in unmoving, the net force on it would have to be zero ($\Sigma F = 0$). We can break up ths sum into the gravitational force and the tension force, taking the downward direction as positive. We can then turn these formulas into their own expanded versions.

$$F_g - \Sigma F_T = 0 \rightarrow m * g = F_g = \Sigma F_{Ty} = T_{1y} + T_{2y}$$

We can find the value of the gravitational force.

$$F_g = m * g = 7\text{kg} * 9.81\text{m/s}^2 = 68.61\text{N}$$

Since the force is divided in two vertically, their vertical tenstion forces should be equal as well.

$$T_{1y} = T_{2y} \rightarrow T_1 \sin(40°) = T_2 \sin(60°)$$

With this, we can find a formula that uses only one unknown tension force (T_2).

$$\begin{aligned}\Sigma F_T &= T_{1y} + T_{2y} = T_1 \sin(40°) + T_2 \sin(60°) \\ &= 2 * T_2 \sin(60°) = T_2\sqrt{3}\end{aligned}$$

We can now substitute this back into an above equation and solve for T_2.

$$\begin{aligned} F_g &= \Sigma F_T \\ 68.61\text{N} &= 2 * T_2 \sin(60^\circ) \\ 68.61\text{N} &= T_2\sqrt{3} \\ T_2 &= 22.87\sqrt{3}\text{N} \\ T_2 &\approx \boxed{39.61\text{N}} \end{aligned}$$

We can repeat the last two steps for T_1.

$$\begin{aligned} \Sigma F_T &= T_{1y} + T_{2y} = T_1 \sin(40^\circ) + T_2 \sin(60^\circ) \\ &= 2 * T_1 \sin(40^\circ) \\ F_g &= \Sigma F_T \\ 68.61\text{N} &= 2 * T_1 \sin(40^\circ) \\ T_1 &= \frac{68.61\text{N}}{2 * \sin(40^\circ)} \\ T_1 &\approx \boxed{53.37\text{N}} \end{aligned}$$

Finally, we have our answer: $\boxed{T_1 = 53.37\text{N} \text{ and } T_2 = 39.61\text{N}}$

Problem 5

A painter of mass M = 75.0 kg stands on a platform of mass m = 15.0 kg. He pulls on a rope that passes around a pulley, as shown in the figure. Find the tension in the rope given that (a) he is at rest, or (b) he accelerates upward at 0.400 m/s^2. (c) If the maximum tension the rope can withstand is 700 N, what happens when he ties the rope to a hook on the wall?

Solution

Section (a)

If the platform is at rest, the