Physics 1408/1420 – General Physics 1

Week of October 10th, 2022

Jorge Martinez-Ortiz

Hello Fellow Physicists,

I am Jorge Martinez-Ortiz, the Master Tutor for Physics this semester. To help you on your journey to learn about this wonderful branch of science and the understanding it gives us of the world around us, I will be preparing this resource every week to give you an additional tool to better prepare for your week. I will also be conducting Group Tutoring sessions every week, the information for which will be given below. If you are unable to attend group tutoring, the tutoring center also offers one-on-one tutoring session, so be sure to visit the tutoring center or visit https://baylor.edu/tutoring.

PHY 1408/1420 General Physics 1 Group Tutoring sessions will be held every Monday from 6:30:7:30 pm in the Sid Richardson building basement, Room 75. See you there!

Over the last week, your professors will have covered Rotation. This week, you will explore Static Equilibrium.

Important Notes
Important Conventions

Keywords: Static Equilibrium, Stress, Strain

Topic of the Week: Static Equilibrium:

These scenarios are also referred to as statics. Statics involves the analysis of all the forces in play within a system that is in equilibrium. A system is in equilibrium when all the forces in a system are balanced. Hence, the sum of forces in the three axes must be as follows:

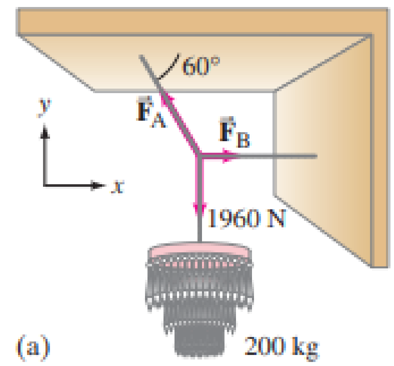
$$\Sigma F_x = 0, \qquad \Sigma F_y = 0, \qquad \Sigma F_z = 0.$$

The most important tool at your disposal is a free body diagram/ dot diagram. Let's look at an example.

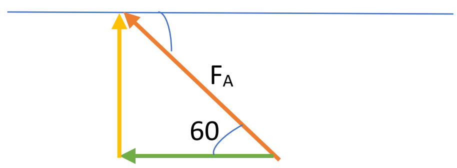
All images are from Physics: Principles with Applications (7th Edition) by Douglas C. Giancoli

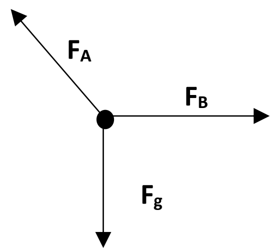
Example

Calculate the tensions F_A and F_B in the two cords that are connected to the vertical cord supporting the 200 kg chandelier.



Solution





The best strategy to approach statics problems is to make a dot diagram and then split the page into two for the analyzing the x and y axes.

$\sum F_Y = 0$

$F_A \sin 60° - F_g = 0$

$F_A \sin 60° = F_g$

$F_A = mg / \sin 60°$

$= (200)(9.8) / \sin 60°$

$= 2260$ N

$\sum F_X = 0$

$-F_A \cos 60° + F_B = 0$

$F_B = F_A \cos 60°$

$= 2260 \cos 60°$

$= 1130$ N

This approach is important because statics will involve many different forces and many of them may act at an angle. Splitting your outlook in two different axes will help simplify your analysis significantly. I highly recommend practicing this approach when dealing with statics.

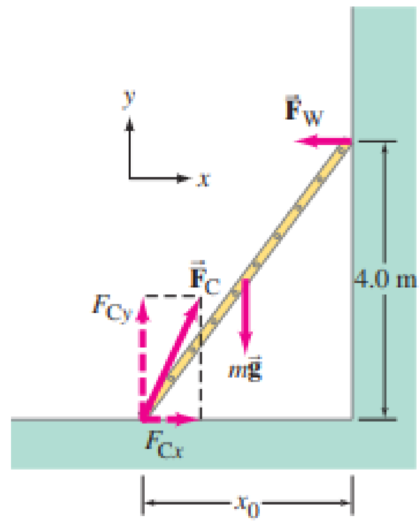
All images are from Physics: Principles with Applications (7th Edition) by Douglas C. Giancoli

Another constant in a system in static equilibrium is the sum of the torques.

$$\Sigma\tau = 0.$$

Let's look at an example using torque

Example:



A 5 m long ladder leans against a wall at a point 4 m above the floor. The ladder has a mass of 12 kg. Assuming the wall is frictionless, but the floor is not, determine the forces exerted on the ladder by the floor and by the wall.

Solution

Y-Axis:

$\sum F_Y = 0$

$F_{Cy} - F_g = 0$

$F_{Cy} = F_g$

$= m\,g$

$= 12 \,.\, 9.8$

$= 118$ N

X-Axis:

$\sum F_X = 0$

$F_{Cx} - F_w = 0$

$F_{Cx} = F_w$

Since both forces are unknown, we will move onto the final torque to see if we can acquire one of the forces

$5^2 = 4^2 + x^2$

$x = 3$

$\sum \tau = 0$

$\tau_{wall} - \tau_{ladder} = 0$

$F_w\, y - F_g\, (x/2) = 0$

$F_w = mg(x/2)/y$

$F_w = (12)(9.8)(3/2) / 4$

$F_w = 44 \text{ N} = F_{Cx}$

$F_C = ((F_{Cx})^2 + (F_{Cy})^2)^{1/2} = ((44)^2 + (118)^2)^{1/2} = 126$ N

All images are from Physics: Principles with Applications (7th Edition) by Douglas C. Giancoli

Highlight: **Elasticity: Stress and Strain**

When it comes to elastic objects, Hooke's law applies when considering the forces they exert or must be exerted on them to cause a displacement. Hooke's law states:

$$F = k\,(l - l_0)$$

But as you may know, there is a limit that an object can be stretched or compressed to before the object breaks. The maximum force that can be applied before breaking object is the called the ultimate strength.

All objects have their own limits. Object can experience stress and strain.

$$\text{stress} = \frac{\text{force}}{\text{area}} = \frac{F}{A}, \qquad \text{strain} = \frac{\text{change in length}}{\text{original length}} = \frac{\Delta \ell}{\ell_0},$$

Based on the type of object, they are subject to three different types of strain and stress, they all dictate different properties about the material. Young's Modulus (E), Shear Modulus(G) and Bulk Modulus (B).

$$\Delta \ell = \frac{1}{E}\frac{F}{A}\ell_0, \qquad \Delta \ell = \frac{1}{G}\frac{F}{A}\ell_0 \qquad \frac{\Delta V}{V_0} = -\frac{1}{B}\Delta P$$

Example

A 1.6 m long steel piano wire has a diameter of 0.2 cm. How great is the tension in the wire if it stretches 0.25 cm when tightened?

Solution

$F = E\,A\,(l - l_0)/l_0$

$= (2 \times 10^{11})(0.0025 / 1.6)(\pi\,(0.0001)^2)$

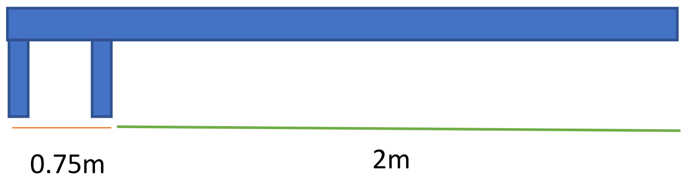
= 980 N

Statics is a highly important topic. Architects and engineers need to consider statics in the design of structures. This process involves knowing the dimensions of the structure and the materials used. The next time you walk into the BSB, take a moment to consider the amazing structure's design and system of forces in play that affected its design.

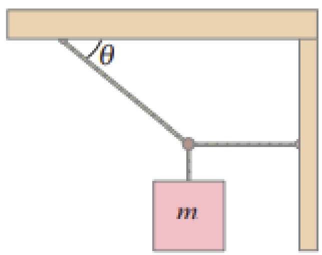
All images are from Physics: Principles with Applications (7th Edition) by Douglas C. Giancoli

CHECK YOUR LEARNING

1. What is the mass of a diver if she exerts a torque of 1200 N.m on a diving board as you see in the figure, relative to the second post? How much force is exerted at the first post by the bolts that anchor the board if the board does not break?



2. Find the tension in the two cords shown in the figure. Assume angle is 40° and mass m is 50 kg.



THINGS YOU MAY STRUGGLE WITH

The most difficult part in this section is determining your initial approach to the problem. The key to solve problems involving systems in static equilibrium is to remember the following rules of thumb:

- For a system in static equilibrium, the NET FORCE and the NET TORQUE along any axis are always zero.
- Forces are typically the best to start with because torque will be clearer if you know all the forces at play.
- If it is not possible to directly calculate the forces with the given information, you can always use the formula relating force and torque to solve for them.

I hope you have a wonderful week! Please feel free to reach out to me if you have any questions and check out all the resources the Tutoring Center has to offer at: https://baylor.edu/tutoring

Answers: 1. 61.22 kg, 1600 N, 2. 762 N for top rope, 584 N for bottom rope

All images are from Physics: Principles with Applications (7th Edition) by Douglas C. Giancoli