USC STEM Spotlight on Aerospace and Mechanical Engineering

Kinematics

Understanding kinematics is fundamental for almost all engineering research. Engineers use kinematics to predict the motion of a solid object. In basic kinematics, an object observed in a specified time frame (t) will have an initial velocity (v_i), a final velocity (v_f), an initial position (x_i), a final position (x_f), and an acceleration (a).

Velocity is a quantity that tells the speed of an object and the direction it is moving.
Acceleration is the rate at which the velocity's speed and direction is changing

Equations of motion for constant acceleration

$$(x_f - x_i) = \tfrac{1}{2}(v_i + v_f)t$$
$$v_f = v_i + at$$
$$x_f - x_i = v_i t + \tfrac{1}{2} at^2$$
$$v_f^2 = v_i^2 + 2a(x_f - x_i)$$

Test your understanding!

A jet flies at a constant speed of 500 miles per hour. How far, in kilometers, does it travel in 28 minutes? [1 mile = 1.61 km]

Typical jetliners require a speed of about 180 miles per hour to take off. If a jetliner takes 32 seconds to takeoff from a starting velocity of 0 mph and has constant acceleration, what is its acceleration in miles/hour^2?

A Lamborghini and an Aston Martin are racing down a straight road. The Lamborghini is travelling at its max speed of 350 km/h and the Aston Martin is travelling at its max speed of 360 km/h. At this instant, the Lamborghini is 1275 meters from the finish line and the Aston Martin is 1300 meters from the finish line. Who will reach the finish line first if they both constantly maintain their top speed?

Torque
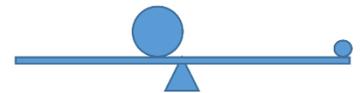
Torque is another tool that engineers use to do several things, including balancing loads. In two-dimensional beam problems, it is a matter of placing the loads at proper distances from the center on each side. The equation for balancing the two sides is shown below.

$$\Sigma(F \times d)_{left\ side} = \Sigma(F \times d)_{Right\ side}$$

You can calculate the product of each load and its respective distance from the center. You can then compare these products on each side to determine if the load is balanced.

Test your understanding!
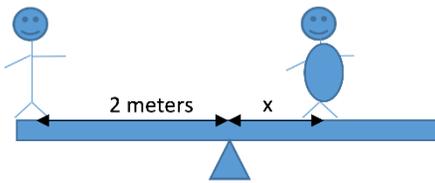
A beam is being balanced using two people. The man on the left has a mass of 61 kg. The man on the right has a mass of 90 kg. If the man on the left is standing 2 meters from the center, how far should the man on the right be standing from the center? (F = mass*9.8 m/s^2)
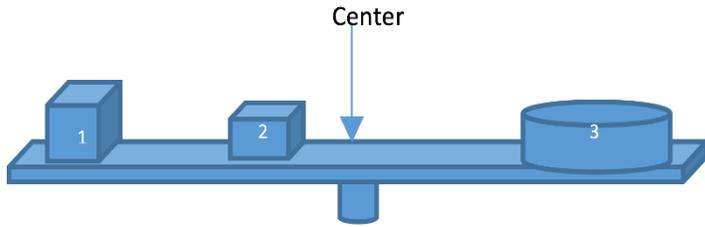
2 meters   x

Center

Object 1 is 4 meters from the center, and object 3 is 4.3 meters from the center. The masses of objects 1, 2, and 3 are 20 kg, 10 kg, and 25 kg, respectively. How many meters from the center should object 2 be for the beam to be balanced?

Fluid Mechanics

Many of the labs you will visit will be within the field of fluid mechanics as aerodynamics is a sub discipline of fluid mechanics. Fluid mechanics is a field of study which observes the interaction of rigid bodies with fluids as well as the motion of fluid itself. It helps us understand why planes fly and why boats can float.

Have you ever used a garden hose and made the flow coming out move faster by pressing on the outside of the end of the hose? This is due to the continuity of fluids! This equation states that the product of the cross-sectional area of a pipe and the speed of the fluid moving through it remains constant throughout the pipe. In the image below, the fluid is travelling faster when is moves through A_2 than A_1 due to the A_2 being smaller than A_1 The equation for continuity of fluids is $A_1 v_1 = A_2 v_2$.

v_1 A_1 A_2 v_2
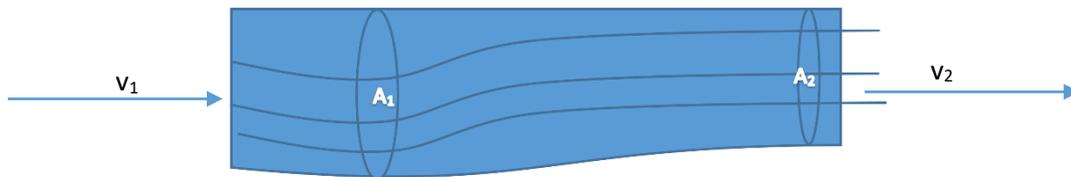
Test your understanding!

In the figure shown above, the water enters the pipe at a velocity of $v_1= 2$ m/s. The radius of the circular cross-sectional area A_1 is 0.5 m. The radius of the circular cross-sectional area A_2 is 0.2 m. What is the exit velocity of the water (v_2) when it leaves the pipe?