# Section 0: Introduction to Physics

## 1. Vector Algebra

Given two vectors in 3D space: $\vec{a} = [2, 1, -3]$ and $\vec{b} = [4, -2, 1]$. Calculate:

a) The magnitude of each vector.

b) The dot product $\vec{a} \cdot \vec{b}$.

c) The cross product $\vec{a} \times \vec{b}$.

d) The angle between vectors $\vec{a}$ and $\vec{b}$.

## 2. Systems of Equations

Find the values of $x$ and $y$ that satisfy both equations: $2x + 3y = 12$ and $x - y = 1$.

## 3. Proportionality

Consider the Universal Law of Gravitation: $F = G\frac{m_1 m_2}{r^2}$, where $F$ is the gravitational force between two masses $m_1$ and $m_2$, $r$ is the distance between their centers, and $G$ is the gravitational constant. Determine the factor by which the force $F$ changes if the distance $r$ is *doubled* and both masses ($m_1$ and $m_2$) are *halved*.

## 4. Rearranging Formulas

The formula for the period of a simple pendulum is $T = 2\pi\sqrt{\frac{L}{g}}$ Rearrange the equation give formula for $g$ (acceleration due to gravity).

## 5. Trigonometry

A vector $\vec{A}$ has a magnitude of 15 and makes an angle of $\theta = 60°$ with the horizontal axis. Calculate its horizontal and vertical components.

## 6. Function Analysis

Consider the function $f(x) = 3x^2 - 12x + 7$. Identify any local maxima or minima.

## 7. Logic & Series

A bicycle is 10 meters from a wall and moves towards it at a constant speed of 1 m/s. A fly starts from the bicycle's front wheel and flies towards the wall at 2 m/s. When it hits the wall, it instantly turns back and flies to the bicycle, and so on. What is the total distance the fly travels before being crushed?

## 8. Definite Integrals

Calculate the area under the curve of the function $f(x) = \sin(x)$ from $x = 0$ to $x = \pi$.

## 9. Optimalization Problem

A rectangle is under the curve $y = 3 - x^2$ in the first quadrant. What are the dimensions of the rectangle with the maximum area?

## 10. Infinite Series

Determine the final position of an ant that starts at the origin and moves according to the following pattern: 1 m east, 1/2 m north, 1/3 m west, 1/4 m south, 1/5 m east, and so on.