Apply Newton's Laws in One-Dimensional Systems

Way to Solve

1. Analyze the problem & draw a force diagram

Identify the question being asked and draw the given conditions on a diagram. Finally, assume and draw the unknown variables on the diagram. Forces should be marked on the object, and velocity and acceleration should be marked next to the object.

2. List the formulas

Based on the force diagram, find the net force on the object and use Newton's second law $F_{\text{net}} = ma$ to write the equation of motion for the object.

3. Find the common variables

In mechanics problems, there may be common variables, such as objects connected by a rope that may have the same speed and acceleration, or two objects in contact that may exert equal and opposite forces on each other.

4. Calculate

After following the above steps, you can calculate the value of the unknown variables.

Sample Problem #1

The cable's "strength" is commonly referred to as the tension at which it snaps. To stop a moving micro unmanned submarine weighing $931\ \text{N}$ ($g = 9.8\ \text{m/s}^2$) within $16\ \text{m}$, what is the minimum strength required for the cable if the submarine initially travels at $24\ \text{m/s}$? Assume that the submarine is under the situation of constant acceleration.

Sol.

Sample Problem #2

Assume a $72\ \mathrm{kg}$ astronaut and a $12\ \mathrm{kg}$ toolbox are floating in the zero-gravity environment of outer space, $28\ \mathrm{m}$ apart but connected by a rope of negligible mass. The astronaut exerts a horizontal $F = 6\ \mathrm{N}$ force on the rope. What are the acceleration magnitudes of (a) the toolbox and (b) the astronaut? (c) How far from the astronaut's initial position do they meet? (d) How many seconds does it take the astronaut to meet the toolbox?

Sol.

Sample Problem #3

A crane is lifting a spring scale, which has a steel plate with a mass of $20\ \mathrm{kg}$ hanging from it. The steel plate is being lifted from the ground to a platform at a height of $245\ \mathrm{m}$. Assuming that $g = 9.8\ \mathrm{m/s^2}$, answer the following questions: (a) If the crane lifts the steel plate at a constant speed, what is the weight displayed on the scale? (b) If the crane lifts the steel plate with constant acceleration and reaches a height of $122.5\ \mathrm{m}$ in the fifth second, what is the weight displayed on the scale during the acceleration period? (c) If the crane starts decelerating in the fifth second and comes to a stop just as it reaches the platform, what is the weight displayed on the scale during this process?

Sol.

Sample Problem #4 [Halliday 5.55]

Sol.

Sample Problem #5

A person and a weight are hanging on opposite sides of a pulley. If the weight's mass is three times that of the person, what is the person's acceleration? If the mass of the person is m, What is the tension T in the rope?

Sol.

Exercises

Exercise #1 [Halliday 5.41]

Sol.

Exercise #2 [Halliday 5.29]

Sol.

Exercise #3 [Halliday 5.48]

Sol.

Exercise #4 [Halliday 5.87]

Sol.

Exercise #5 [Halliday 5.54]

Sol.

Exercise #6 [Halliday 5.43]

Sol.

Exercise #7 [Halliday 5.69]

Sol.

Exercise #8 [Halliday 5.50]

Sol.

Exercise #9 [Halliday 5.51]

Sol.

Exercise #10 [Halliday 5.59]

Sol.