How to Solve a Two-Body Problem

Lesson Notes

Learning Outcomes

- How do you use a free-body diagram and Newton's second law to analyze and solve a two-body problem?

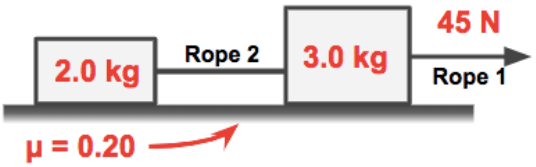
The Basic Approach to Solving a Two-Body Problem

The solution to a two-body problem will typically include two analyses:

- **A System Analysis**: Used to determine the acceleration
- **An Individual Object Analysis**: Used to determine an "internal force"

Example 1

A 2.0-kg and a 3.0-kg object are connected by a rope. A 45.0-N tension force is exerted on the 3.0-kg object to accelerate them across the rough surface (μ=0.20). Determine the acceleration and the tension in Rope 2.

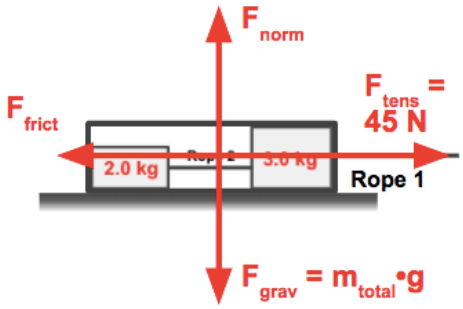


Step 1: System Analysis

$m_{total} = 5.0\ kg$

$F_{grav} = (5.0\ kg)\bullet(9.8\ N/kg)$

$F_{grav} = F_{norm} = 49\ N$



$F_{frict} = \mu\bullet F_{norm} = (0.20)\bullet(49\ N) = 9.8\ N$

$F_{net} = F_{tens} - F_{frict}$

$F_{net} = 45.0\ N - 9.8\ N$

$F_{net} = 35.2\ N$

$a = F_{net} / m_{total}$

$a = (35.2\ N)/(5.0\ kg)$

$a = 7.0\ m/s/s$

(7.04 m/s/s)

Step 2: Individual Object Analysis

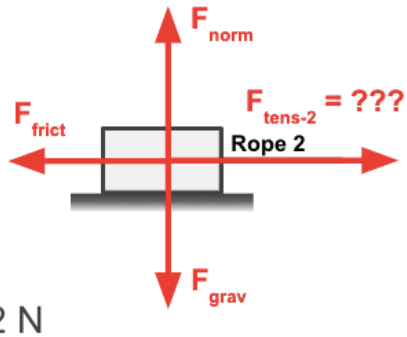
Consider $\mathbf{m_2}$: $m_2 = 2.0\ kg$

$F_{grav} = (2.0\ kg)\bullet(9.8\ N/kg)$

$F_{grav} = F_{norm} = 19.6\ N$

$F_{frict} = \mu\bullet F_{norm}$

$F_{frict} = (0.20)\bullet(19.6\ N) = 3.92\ N$



$a_{system} = a_2 = 7.04\ m/s/s$

$F_{net} = m_2\bullet a_2$

$F_{net} = (2.0\ kg)\bullet(7.04\ m/s/s)$

$F_{net} = 14.08\ N$

$F_{net} = F_{tens\text{-}2} - F_{frict}$

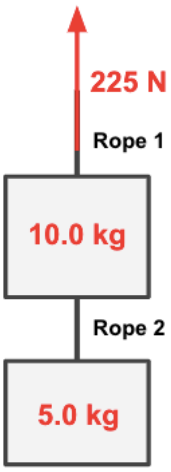
$14.08\ N = F_{tens\text{-}2} - 3.92\ N$

$F_{tens\text{-}2} = 14.08\ N + 3.92\ N$

$F_{tens\text{-}2} = 18\ N$

Example 2

A 5.0-kg and 10.0-kg object are connected by a rope. A second rope is used to exert 225-N of force on the 10.0-kg object. Determine the acceleration and tension in the lower rope.



Step 1: System Analysis

m_{total} = 15.0 kg

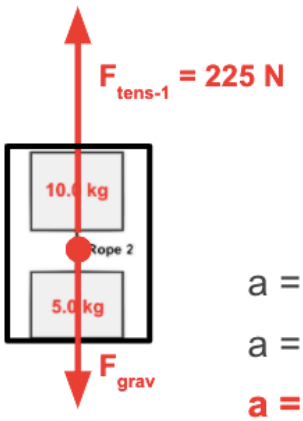
F_{grav} = (15.0 kg)•(9.8 N/kg)

F_{grav} = 147 N

$F_{net} = F_{tens-1} - F_{grav}$

F_{net} = 225 N - 147 N

F_{net} = 78 N



$a = F_{net} / m$

a = (78 N)/(15 kg)

a = 5.2 m/s/s

Step 2: Individual Object Analysis

Consider $\mathbf{m_2}$: m_2 = 5.0 kg

F_{grav} = (5.0 kg)•(9.8 N/kg)

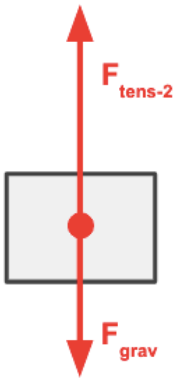
F_{grav} = 49 N

$a_{system} = a_2$ = 5.2 m/s/s

F_{net} = m•a

F_{net} = (5.0 kg)•(5.2 m/s/s)

F_{net} = 26 N



$F_{net} = F_{tens-2} - F_{grav}$

26 N = F_{tens-2} - 49 N

F_{tens-2} = 75 N