Physics 4A
Chapter 7: Newton's Third Law

"What we see depends mainly on what we look for." – John Lubbock

"Your thoughts are the architects of your destiny." – David O. McKay

Reading: pages 164 – 174

Outline:

⇒ Newton's 3rd Law
⇒ Ropes and Pulleys
⇒ Example Problems

IMPORTANT CONCEPTS

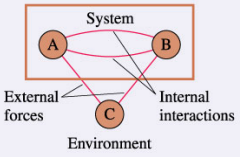
Objects, systems, and the environment

Objects whose motion is of interest are the system.

Objects whose motion is not of interest form the environment.

The objects of interest interact with the environment, but those interactions can be considered external forces.

Interaction diagram



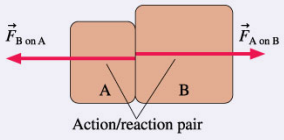
GENERAL PRINCIPLES

Newton's Third Law

Every force occurs as one member of an **action/reaction pair** of forces. The two members of an action/reaction pair:

- Act on two *different* objects.
- Are equal in magnitude but opposite in direction:

$$\vec{F}_{\text{A on B}} = -\vec{F}_{\text{B on A}}$$



Solving Interacting-Objects Problems

MODEL Identify which objects form the system.

VISUALIZE Draw a pictorial representation.

- Define symbols and coordinates.
- Identify acceleration constraints.
- Draw an interaction diagram.
- Draw a separate free-body diagram for each object.
- Connect action/reaction pairs with dashed lines.

SOLVE Write Newton's second law for each object.

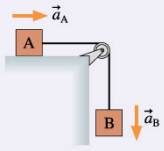
- Use the free-body diagrams.
- Equate the magnitudes of action/reaction pairs.
- Include acceleration constraints and friction.

ASSESS Is the result reasonable?

APPLICATIONS

Acceleration constraints

Objects that are constrained to move together must have accelerations of equal magnitude: $a_A = a_B$. This must be expressed in terms of components, such as $a_{Ax} = -a_{By}$.

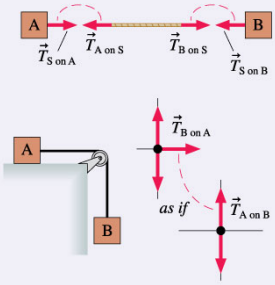


Strings and pulleys

The tension in a string or rope pulls in both directions. The tension is constant in a string if the string is:

- Massless, or
- In equilibrium

Objects connected by massless strings passing over massless, frictionless pulleys act *as if* they interact via an action/reaction pair of forces.



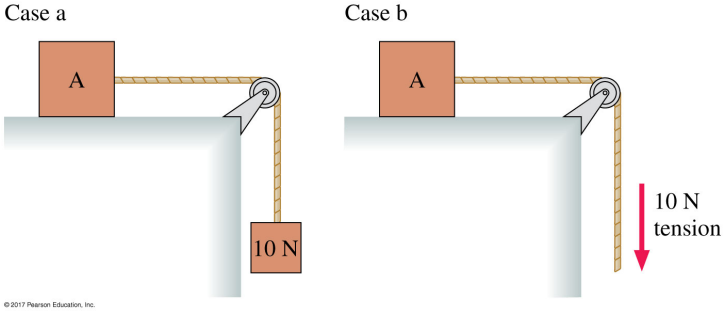
Conceptual Questions and Example Problems from Chapter 7

Conceptual Question 7.2
How does a sprinter sprint? What is the force on a sprinter as she accelerates? Where does that force come from?

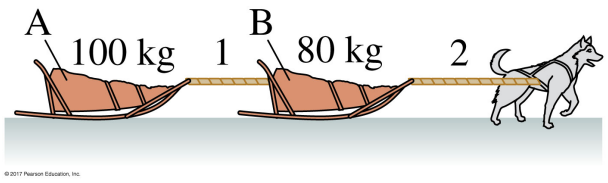
Conceptual Question 7.5
A mosquito collides head-on with a car traveling at 60 mph. Is the force of the mosquito on the car larger than, smaller than, or equal to the force of the car on the mosquito? Explain.

Conceptual Question 7.6
A mosquito collides head-on with a car traveling at 60 mph. Is the magnitude of the mosquito's acceleration larger than, smaller than, or equal to the magnitude of the car's acceleration?

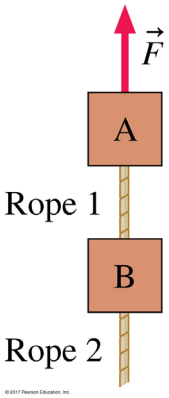
Conceptual Question 7.15
In case a in the figure below, block A is accelerated across a frictionless table by a hanging 10 N weight (1.02 kg). In case b, block A is accelerated across a frictionless table by a steady 10 N tension in the string. The string is massless, and the pulley is massless and frictionless. Is A's acceleration in case b greater than, less than, or equal to its acceleration in case a? *Explain.*



Problem 7.14
The sled dog in the figure below drags sleds A and B across the snow. The coefficient of friction between the sleds and the snow is 0.10. If the tension in rope 1 is 150 N, what is the tension in rope 2?

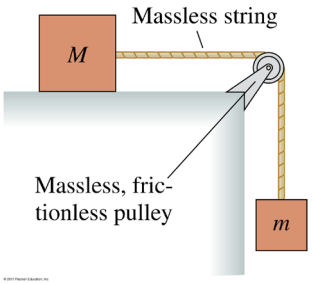


Problem 7.16
The figure to the right shows two 1.0 kg blocks connected by a rope. A second rope hangs beneath the lower block. Both ropes have a mass of 250 g. The entire assembly is accelerated upward at 3.0 m/s^2 by force F. **(a)** What is F? **(b)** What is the tension at the top end of rope 1? **(c)** What is the tension at the bottom end of rope 1? **(d)** What is the tension at the top end of rope 2?

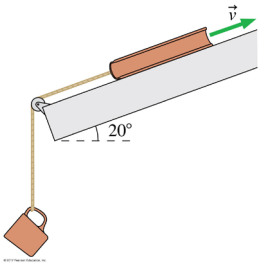


Problem 7.20
Two blocks are attached to opposite ends of a massless rope that goes over a massless, frictionless, stationary pulley. One of the blocks, with a mass of 6.0 kg, accelerates downward at ¾ g. What is the mass of the other block?

Problem 7.36
The block of mass M in the figure to the right slides on a frictionless surface. Find an expression for the tension in the string.



Problem 7.41
The 1.0 kg physics book in the figure below is connected by a string to a 500 g coffee cup. The book is given a push up the slope and released with a speed of 3.0 m/s. The coefficients of friction are $\mu_s = 0.50$ and $\mu_k = 0.20$. (a) How far does the book slide? (b) At the highest point, does the book stick to the slope, or does it slide back down?



Problem 7.A (Problem from Exam 1 – Spring 2002)
In the figure below, two blocks are connected over a frictionless, massless pulley. The weight of block A is 50 N and the coefficient of static friction between block A and the incline is 0.20. The angle θ of the incline is 30.0°. What is the maximum and minimum mass that block B can have such that both blocks remain stationary?