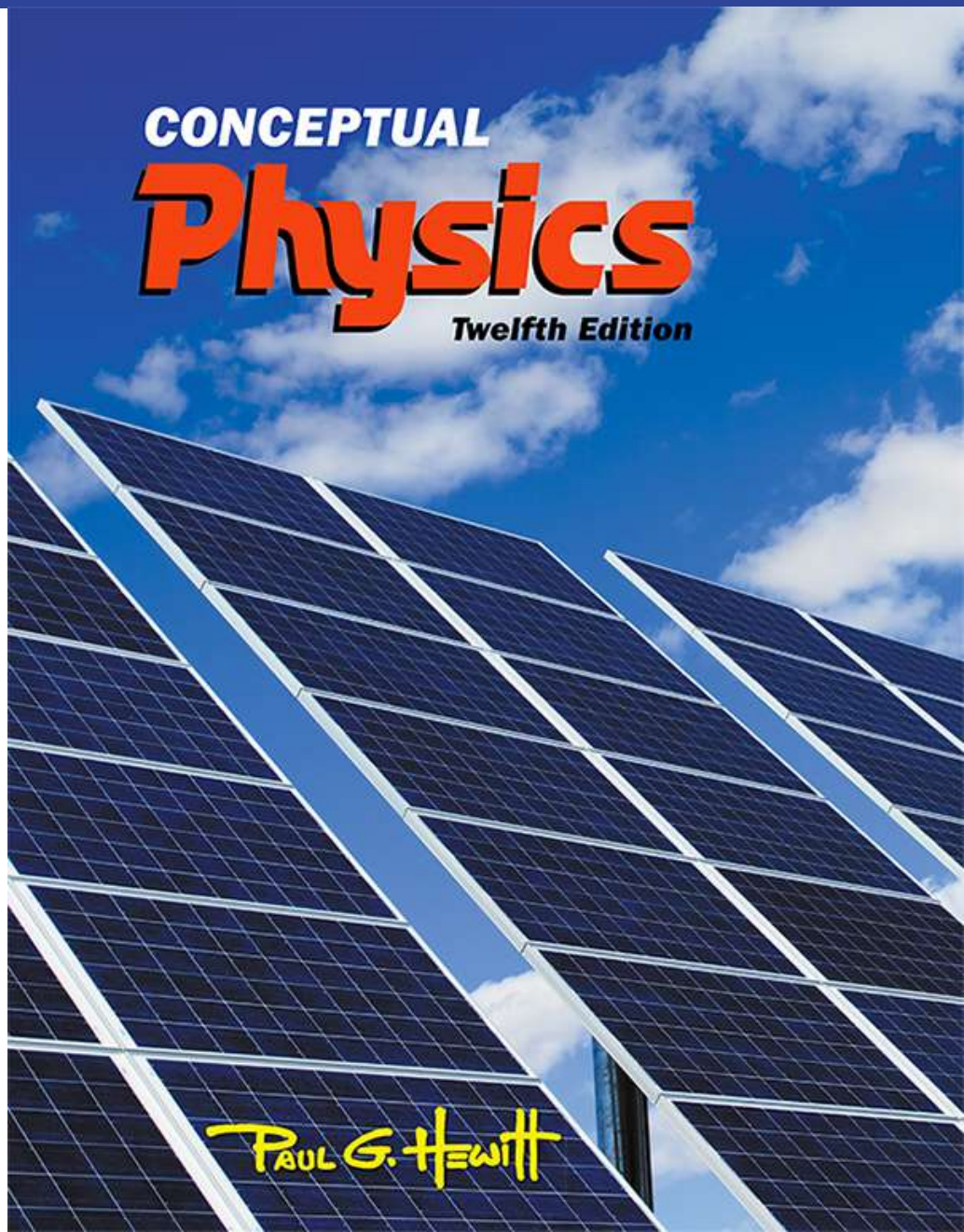
Lecture Outline

Chapter 5: Newton's Third Law of Motion

This lecture will help you understand:

Forces and Interactions

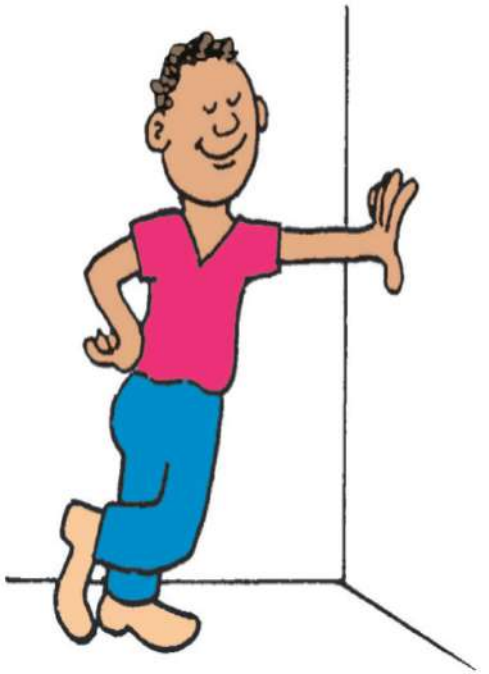
Newton's Third Law of Motion



Forces and Interactions

- Interaction
  - is between one thing and another.
  - requires a pair of forces acting on two objects.

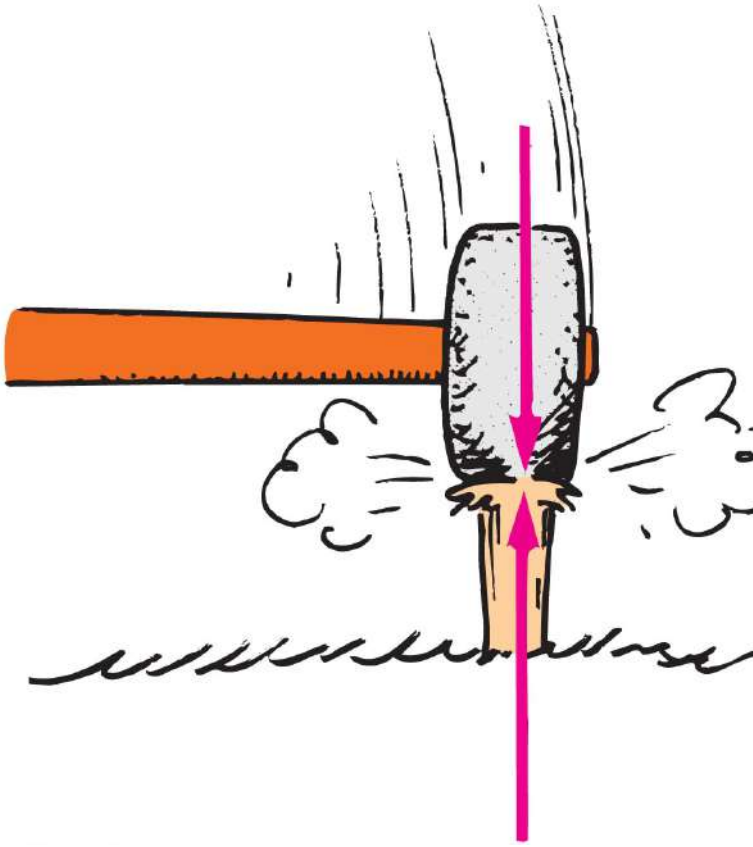
- Example: interaction of hand and wall pushing on each other
  Force pair—you push on wall; wall pushes on you.



Newton's Third Law of Motion

- *Whenever one object exerts a force on a second object, the second object exerts an equal and opposite force on the first.*

- *What are the 2 forces here?*



Newton's Third Law of Motion
CHECK YOUR NEIGHBOR

A soccer player kicks a ball with 1500 N of force. The ball exerts a reaction force against the player's foot of

A. somewhat less than 1500 N.
B. 1500 N.
C. somewhat more than 1500 N.
D. None of the above.

Newton's Third Law of Motion
CHECK YOUR ANSWER

A soccer player kicks a ball with 1500 N of force. The ball exerts a reaction force against the player's foot of

B. 1500 N.

Newton's Third Law of Motion, Continued

- Action and reaction forces
  - one force is called the *action* force; the other force is called the *reaction* force.
  - are co-pairs of a single interaction.
  - neither force exists without the other.
  - are equal in strength and opposite in direction.
  - always act on *different* objects.

Newton's Third Law of Motion, Continued-1

- Re-expression of Newton's third law:
- **To every action there is always an opposed equal reaction.**
- Example: Tires of car push back against the road while the road pushes the tires forward.

Action: tire pushes on road

Reaction: road pushes on tire

Newton's Third Law of Motion, Continued-2

- Simple rule to identify action and reaction
  - Identify the interaction—one thing interacts with another
    - Action: Object A exerts a force on object B.
    - Reaction: Object B exerts a force on object A.
- Ex.

  Bat hits ball forward with a 300 N force.

  Ball hits bat backward with a 300 N force.

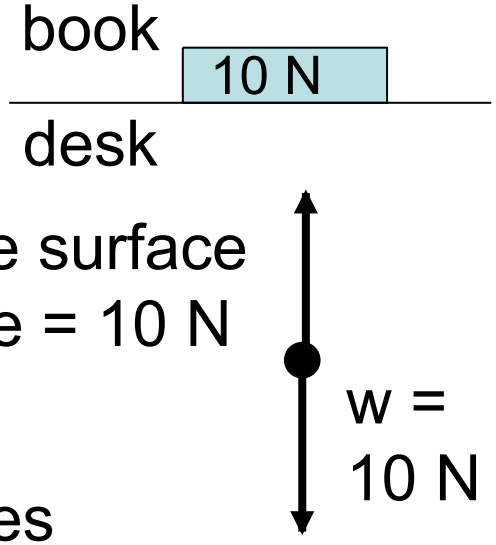
  Which force has a bigger magnitude (size)?

  neither

  Describe the directions of the 2 forces. opposite

IMPORTANT:
Action and Reaction Forces act on different objects!

Ex. A 10-N book sits on a desk.



A) Draw the forces acting on the book:

B) Are these forces equal and opposite? yes

C) Are these 2 forces an action-reaction pair? no

D) Explain. they act on the same object,
so they cannot be an action-reaction pair

Newton's Third Law of Motion
CHECK YOUR NEIGHBOR, Continued

When you step off a curb, Earth pulls you downward. The reaction to this force is

A. a slight air resistance.
B. nonexistent in this case.
C. you pulling Earth upward.
D. None of the above.

C. you pulling Earth upward.

Newton's Third Law of Motion
CHECK YOUR NEIGHBOR, Continued

When you step off a curb, Earth pulls you downward. You pull Earth upward. Which force is stronger?

A. Earth pulling you.
B. You pulling Earth.
C. Impossible to tell.
D. Same magnitude (strength).

D. Same magnitude (strength).

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Newton's Third Law of Motion
CHECK YOUR NEIGHBOR, Continued-3

Consider a high-speed bus colliding head-on with a flying bug. The force of impact splatters the unfortunate bug over the windshield. Which is greater, the force on the bug or the force on the bus?

A. Bug
B. Bus
C. Both the same amount.
D. Cannot say

C. Both the same amount.

- **Comment:**
- Although the forces are equal in magnitude, the effects are very different. Do you know why?

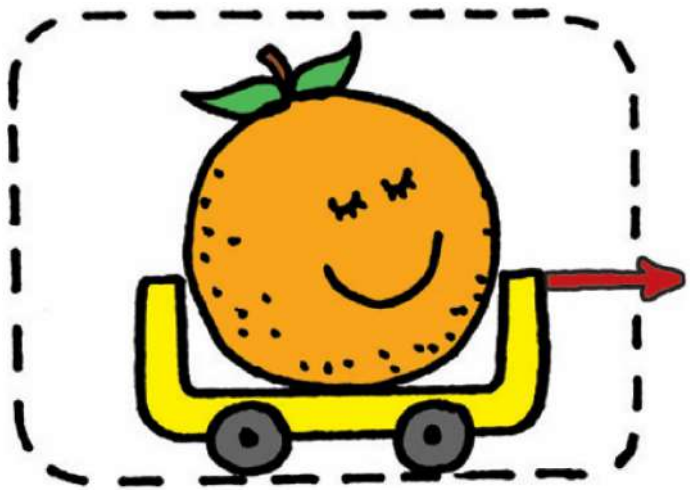
Example: Pushing yourself forward

- You sit in a car at rest.
- Can you make the car move forward by pushing or pulling on the steering wheel?

- Explain:
- You push on the steering wheel.
- The steering wheel pushes back on you.
- Both forces are *internal*….they cancel out.
- You cannot move the car forward this way.
- You need an *external* force to accelerate you!

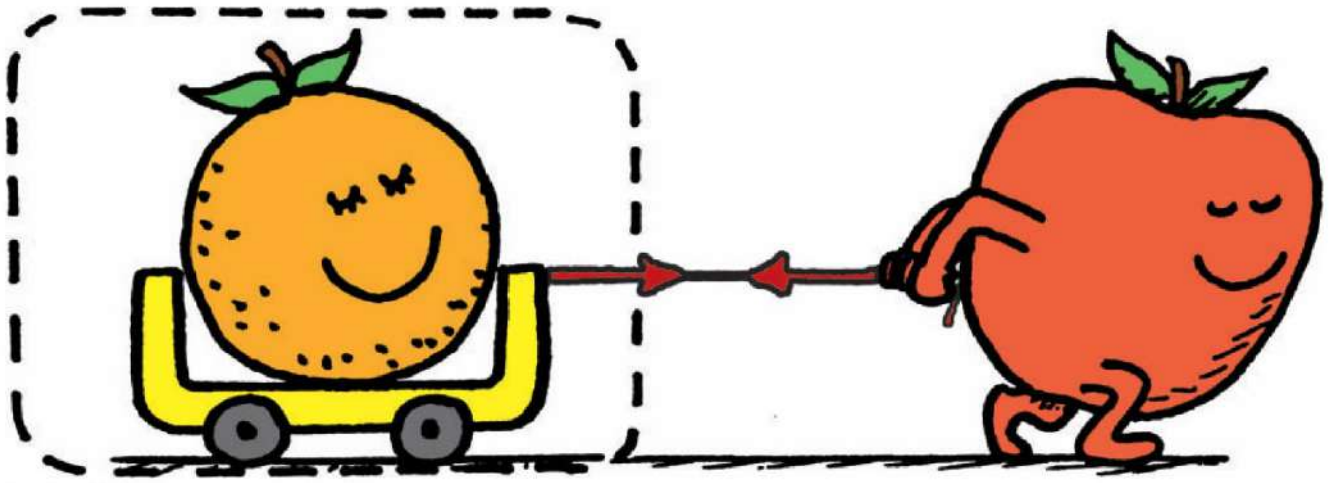
Newton's Third Law of Motion, Continued-4

- Defining Your System
  - Consider a single enclosed orange.
    - Applied external force causes the orange to accelerate in accord with Newton's second law.
    - We see here only the action force (red vector).



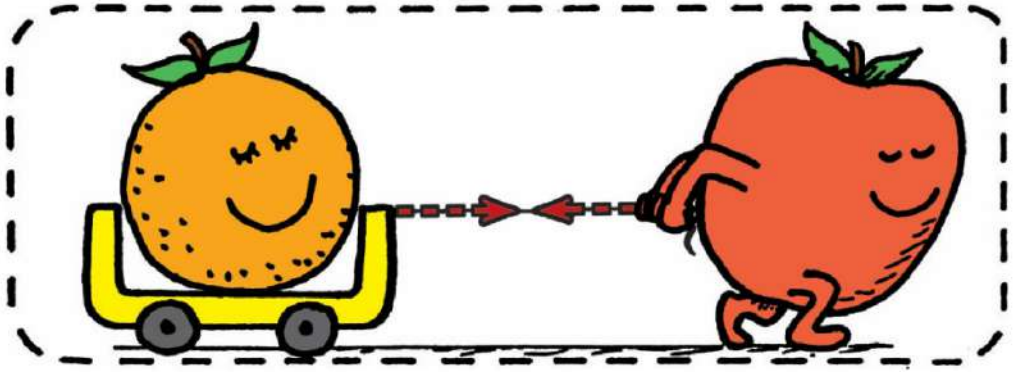
Newton's Third Law of Motion, Continued-5

- Consider the orange and the apple pulling on it.
  - Action and reaction do not cancel (because they act on different objects).
  - External force by apple accelerates the orange.



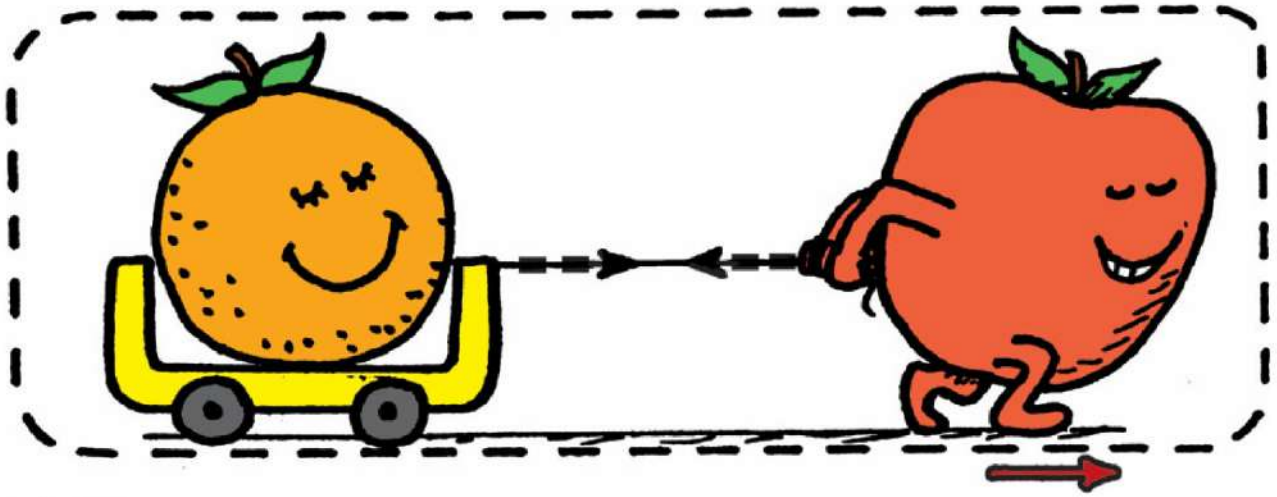
Newton's Third Law of Motion, Continued-6

- Consider a system comprising both the orange and the apple.
  - The apple is no longer external to the system.
  - Force pair is internal to the system, which doesn't cause acceleration.
  - Action and reaction within the system cancel.
  - With no external forces, there is no acceleration of the system.



Newton's Third Law of Motion, Continued-7

- Aha! Here's the same system, but with external force of friction on it (friction between the apple's feet and the floor).
- External frictional force of the floor accelerates the system.



How do you move, Part A?

Ex. You want to walk to the right.

A) Which direction must you push on the floor?

to the left

B) What pushes you to the right?

the floor

C) If the floor is very slippery (no friction), why can't you move to the right?

floor cannot push

D) What force keeps you in one place?

Not a force…your inertia (property of matter)

How do you move, part B?

Ex. A car needs to drive north.

A) Which way must the tires push on the road?

to the south

B) What pushes the car to the north?

the road

C) If the road is very icy (no friction), why can't the car drive north?

road cannot push

D) What force keeps the car from moving?

Not a force…your inertia (property of matter)

How do you move, part C?

Ex. A propellor plane want to fly west.

A) What does the propellor push on?

air

B) What direction does it push?

to the east

C) What pushes the plane forward?

the air

D) Why is it more difficult to fly at higher altitudes?

not enough air to push on

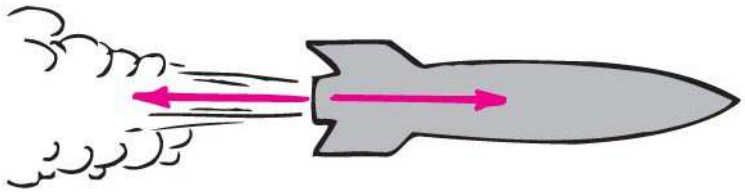
How do you move, part C?

Ex. A rocket needs to leave Earth. The rocket pushes gases down towards Earth.

A) What pushes the rocket away?

the gases it pushes down

B) Does the rocket need air to push on? no

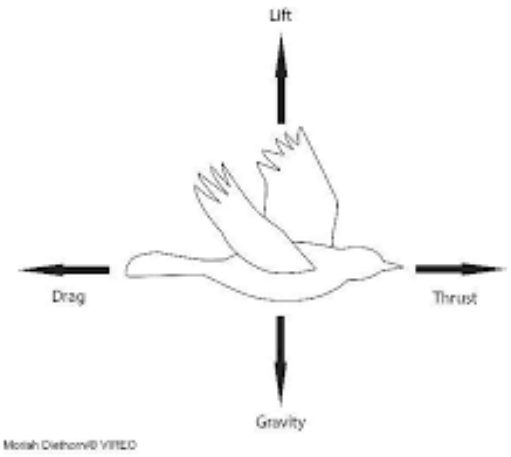


Action: rocket pushes on gas Reaction: gas pushes on rocket

C) Why is it more difficult when there is air around?

air resistance opposes the air force

Newton's Third Law of Motion
CHECK YOUR NEIGHBOR

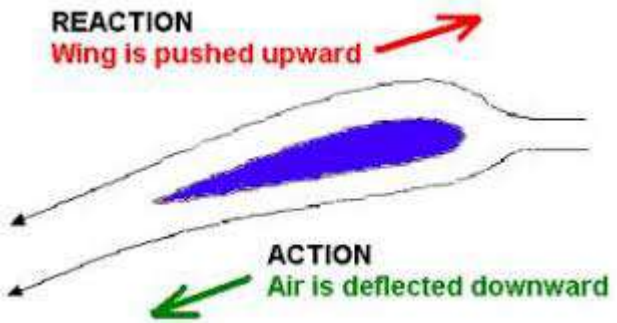


A bird flies by

A. flapping its wings.
B. pushing air down so that the air pushes it upward.
C. hovering in midair.
D. inhaling and exhaling air.

B. pushing air down so that the air pushes it upward.

Newton's Third Law of Motion
CHECK YOUR NEIGHBOR



Slightly tilted wings of airplanes deflect

A. oncoming air downward to produce lift.
B. oncoming air upward to produce lift.
C. Both A and B.
D. Neither A nor B.

A. oncoming air downward to produce lift.

- **Explanation:**
- When a wing diverts air downward, it exerts a downward force on the air. The air simultaneously exerts an upward force on the wing. The vertical component of this upward force is lift. (The horizontal component is drag.)

Newton's Third Law of Motion
CHECK YOUR NEIGHBOR

Compared with a lightweight glider, a heavier glider would have to push air

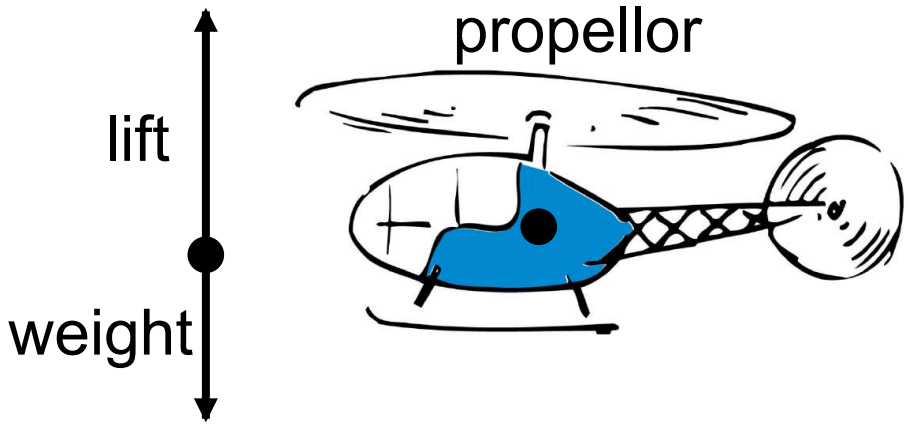
A. downward with greater force.
B. downward with the same force.
C. downward with less force.
D. None of the above.

A. downward with greater force.

- **Explanation:**
- The force on the air deflected downward must equal the weight of the glider.

Newton's Third Law of Motion
CHECK YOUR NEIGHBOR, Continued-6

Consider the flight of a helicopter. *Lift* is caused by the air pushing the propellor upward.



A) What is the reaction force to the lift?

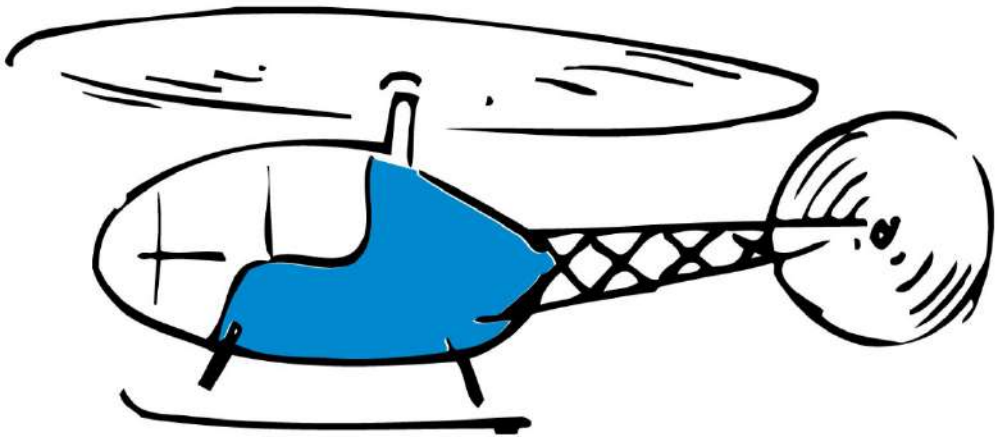
propellor pushes air downward

A) What is the reaction force to the weight?

propellor pushes air downward

Newton's Third Law of Motion
CHECK YOUR ANSWER, Continued-6

When lift is greater than the helicopter's weight, the helicopter



A. moves downward.
B. moves upward.
C. hovers in midair.
D. None of the above.

B. moves upward.

Homework: due Tomorrow by 7 pm

- On page 85:
- Reading Check Questions #1-9

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