

Physics 2A

Chapter 4 HW Solutions

Chapter 4

Conceptual Question: 5, 8, 10, 18

Problems: 3, 23, 35, 48, 50, 54, 61, 65, 66, 68

Q4.5. Reason: No. If you know all of the forces than you know the direction of the acceleration, not the direction of the motion (velocity). For example, a car moving forward could have on it a net force forward if speeding up or backward if slowing down or no net force at all if moving at constant speed.

Assess: Consider carefully what Newton's second law says, and what it doesn't say. The net force must *always* be in the direction of the acceleration. This is also the direction of the *change* in velocity, although not necessarily in the direction of the velocity itself.

Q4.8. Reason: (a) During the first collision a person in the car continues in their state of motion until a force acts to change their motion. This will happen when the seatbelt engages or when the person hits something on the inside of the car. Likewise, internal organs will continue in their state of motion until some force acts on them to change their motion. They continue moving due to Newton's first law.

(b) If there is no restraint on the body after the first collision, the body will be moving at 60 mph just before the second collision, and the organs will be traveling at this speed until just before the third collision.

Assess: Forces are required to change an object's state of motion.

Q4.10. Reason: Since there is no source of gravity, you will not be able to feel the weight of the objects. However, Newton's second law is true even in an environment without gravity. Assuming you can exert a reproducible force in throwing both objects. You could throw each and note the acceleration each obtains.

Assess: Mass is independent of the force of gravity and exists even in environments with no sources of gravity.

Q4.18. Reason: The two forces in question are both exerted on the same object, the filing cabinet. An action/reaction pair is exerted on two different objects. As Alyssa pushes to the right on the filing cabinet, the filing cabinet pushes on Alyssa an equal amount to the left. These two forces constitute an action/reaction pair – note that one force acts on Alyssa and the other force acts on the filing cabinet. The two forces of the action/reaction pair act on different objects. As the frictional force of the floor pushes on the filing cabinet to the left, the filing cabinet pushes on the floor an equal amount to the right. These two forces also constitute an action/reaction pair.

Assess: It is important to remember that the forces of an action/reaction pair act on different objects.

P4.3. Prepare: As background, look at question Q4.8 and problem P4.1. Also think about the design and orientation of the seat and how the child rides in the seat. Finally recall Newton's second law.

Solve: As the child rides in the seat, his/her head and back rest against the padded back of the seat. If the car is brought to a rapid stop (as in a head-on collision) the child will continue to move forward at the before-crash speed until he/she hits something. The object hit is the back of the seat (supporting the entire back and head) which is padded and as a result the force increases to the maximum value over a time interval. Granted this time interval may be small but that is considerable better than instantaneous. Also since the head is supported, there will be no whip-lash.

Assess: The fact the force acting on the child is spread over a small time interval is a critical factor. In later chapters you will learn to call this concept impulse.

P4.23. Prepare: We can use our knowledge of kinematics and our conceptual understanding of acceleration to determine the acceleration of the car and then Newton's second law to determine the force acting on the car.

Solve: First let's determine the acceleration of the car.

$$a = \Delta v / \Delta t = (v_f - v_i) / \Delta t = \left(21 \frac{\text{m}}{\text{s}} - 20 \frac{\text{m}}{\text{s}} \right) / 2.0 \text{s} = 0.50 \text{m/s}^2$$

Next, let's determine the force acting on the car.

$$F = ma = (1500 \text{kg})(0.50 \text{m/s}^2) = 7.5 \times 10^2 \text{N}$$

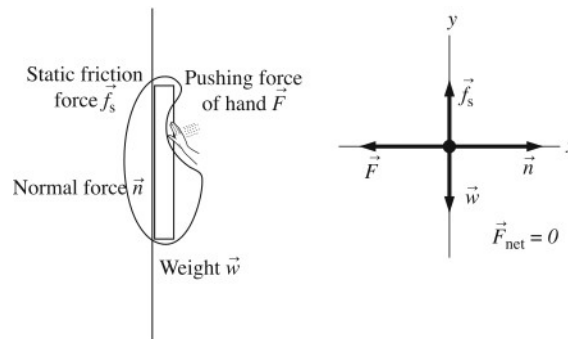
Assess: It should be noted that even though we are in chapter 4 and dealing primarily with forces, it is critical that we stay up on the content of previous chapters.

P4.35. Prepare: We follow the steps outlined in Tactics Boxes 4.2 and 4.3.

Solve: The system is the picture.

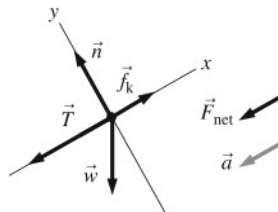
The objects in contact with the picture are the wall and your hand. The wall exerts a normal force (opposite the pushing force of the hand) and a static friction force, which is directed upward and prevents the picture from falling down.

The important long-range force is the gravitational force of the earth on the picture (i.e., the weight).



Assess: The net force is zero, as it should be for an object which is motionless (isn't accelerating).

P4.48. Prepare: Redraw the motion diagram as shown.



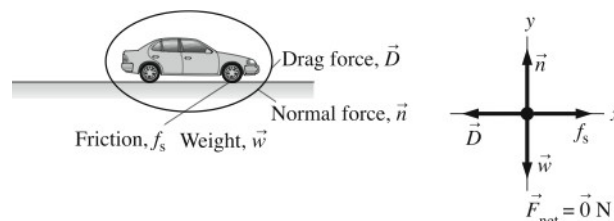
Solve: (a)–(c) There is an object on an inclined surface with a tension force down the surface. There is a small frictional force up the surface implying that the object is sliding down the slope. The force vector and the acceleration vector are in the same direction.

(d) A description could be, "A sled is being pulled down a slope with a rope that is parallel to the slope."

Assess: Knowing that kinetic friction opposes the motion of an object, we are able to establish that the sled is travelling down the slope. It is essential that we look at all the forces and the nature of these forces to accurately determine what will happen to the object.

P4.50. Prepare: Refer to Tactics Box 4.2 and Tactics Box 4.3 for identification of forces and for drawing free-body diagrams. We will draw a correct free-body diagram and compare.

Solve: Your car is the system. See the following diagram.



There are contact forces where the car touches the road. One of them is the normal force of the road on the car. The other is the force of static friction between the car's tires and the road since the car is moving. Compare to Figure 4.32 and the discussion of propulsion in the text.

In addition to this there must be a force in the opposite direction to the car's motion, since the car is moving at constant speed. If only the frictional force acted in the horizontal direction, the car would be accelerating! The diagram omits one of the forces. A possible force that acts in this direction is the force of air drag on the car, which is indicated on the diagram.

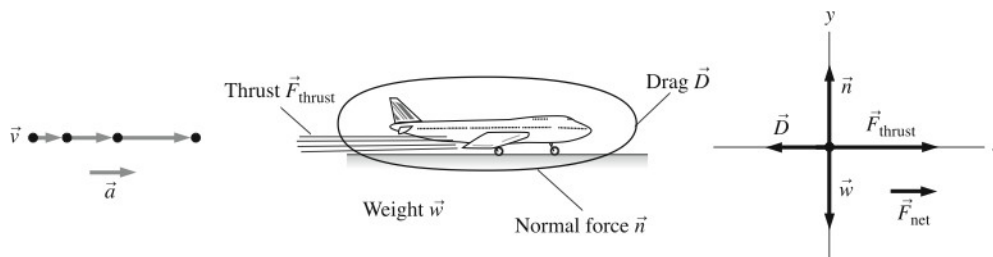
The only long-range force acting is the weight of the car.

The diagram also identifies the weight of the car and the normal force on the car as an action/reaction pair. This isn't possible, since both these forces act on the same object, while action/reaction pairs always act on *different* objects. The normal force on an object and its weight are *never* action/reaction pairs.

Assess: In order for an object to be moving at constant velocity, the net force on it must be zero. Action/reaction pairs always act on two different objects.

P4.54. Prepare: The normal force is perpendicular to the ground. The thrust force is parallel to the ground and in the direction of acceleration. The drag force is opposite to the direction of motion. There are four forces acting *on* the jet plane due to its interactions with the four agents the earth, the air, the ground, and the hot gases exhausted to the environment. One force on the rocket is the long-range weight force *by* the earth. The second force is the drag force *by* the air. Third is the normal force on the rocket *by* the ground. The fourth is the thrust force exerted on the jet plane *by* the hot gas that is being let out to the environment. Since the jet plane is speeding down the runway, its acceleration is pointing to the right. Therefore, the net force on the jet plane must also point to the right.

Now, draw a picture of the situation, identify the system, in this case the jet plane, and draw a motion diagram. Draw a closed curve around the system, and name and label all relevant contact forces and long-range forces.

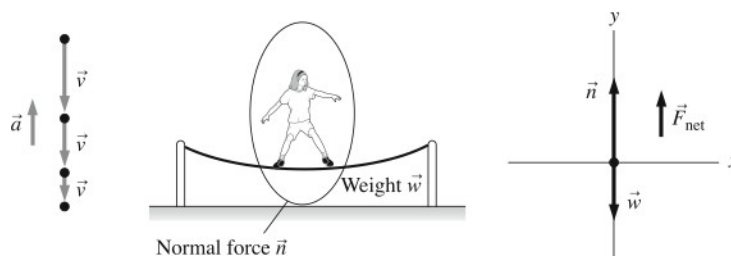


Solve: A force-identification diagram, a motion diagram, and a free-body diagram are shown.

Assess: You now have three important tools in your "Physics Toolbox," motion diagrams, force diagrams, and free-body diagrams. Careful use of these tools will give you an excellent conceptual understanding of a situation.

P4.61. Prepare: The gymnast experiences the long range force of weight. There is also a contact force from the trampoline, which is the normal force of the trampoline on the gymnast. The gymnast is moving downward and the trampoline is decreasing her speed, so the acceleration is upward and there is a net force upward. Thus the normal force must be larger than the weight. The actual behavior of the normal force will be complicated as it involves the stretching of the trampoline and therefore tensions.

Now, draw a picture of the situation, identify the system, in this case the gymnast, and draw a motion diagram. Draw a closed curve around the system, and name and label all relevant contact forces and long-range forces.

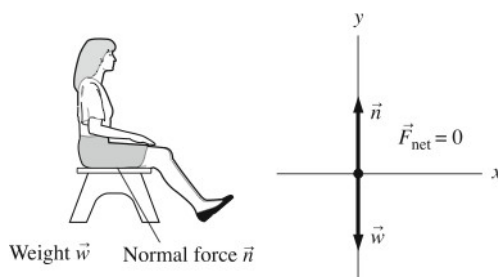


Solve: A force-identification diagram, a motion diagram, and a free-body diagram are shown.

Assess: There are only two forces on the gymnast. The weight force is directed downward and the normal force is directed upward. Since the gymnast is slowing down right after after making contact with the trampoline, upward normal force must be larger than the downward weight force.

P4.65. Prepare: To solve this problem, we will need to think carefully about the forces acting on the object of interest (the passenger in the car). It will also be important to determine what is meant by a *very* slippery bench.

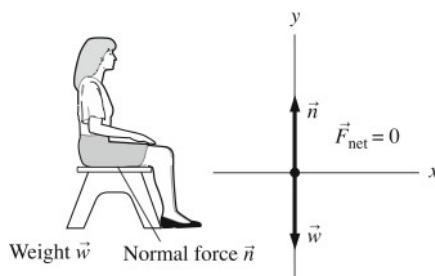
Solve:



(a) The passenger is sitting on a *very* slippery bench in a car that is traveling to the right. Both the passenger and the seat are moving with a constant speed. There is a force on the passenger due to her weight, which is directed down. There is a contact force (the normal force) between the passenger and the seat, which is directed up. Since the passenger is not accelerating up or down, the net vertical force on her is zero, which means the two vertical forces are equal in magnitude. The statement of the problem gives no indication of any other contact forces. Specifically, we are told that the seat is *very* slippery. We can take this to mean there is no frictional force. So our force diagram includes only the normal force up, the weight down, but no horizontal force.

(b) The above considerations lead to the free-body diagram shown in the previous figure.

(c) The car (and therefore the *very slippery* seat) begins to slow down. Since the seat cannot exert a force of friction (either static or kinetic) on the passenger, the passenger cannot slow down as fast as the seat which is attached to the car. As a result the passenger continues to move forward with the initial speed of the car. Since the forces acting on the passenger remain the same, the free-body diagram is unchanged but the pictorial representation of the passenger is changed. These are shown in the following diagram.



(d) The car slows down because of some new contact force on the car (maybe the brakes lock the wheels and the road exerts a force on the tires). But there is no new contact force on you *the passenger*. The force diagram for the passenger remains unchanged, there are no horizontal forces on you. You do not slow down, but rather continue at an unchanged velocity until something in the picture changes for you (for example, you slide off the seat or hit the windshield). (e) The net force on you has remained zero because the net vertical force is zero and there are no horizontal forces. According to Newton's first law, if the net force on you is zero, then you continue to move in a straight line with a constant velocity. That is what happens to you when the car slows down. You continue to move forward with a constant velocity. The statement that you are "thrown forward" is misleading and incorrect. To be "thrown" there would need to be a net force on you and there is none. It might be correct to say that the car has been "thrown backward" leaving you to continue onward (until you part company with the seat).

Assess: Careful thinking and precise language, aided by a good diagram and understanding of Newton's first and second laws, are needed to articulate the solution of this problem.

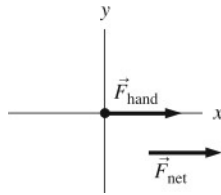
P4.66. Prepare: Assume the ball undergoes constant acceleration during the pitch so we can use the kinematic equations in Table 2.4.

$$(v_x)_f^2 = (v_x)_i^2 + 2a_x \Delta x$$

Use coordinates where +x is in the direction the ball is thrown. We are given $\Delta x = 1.0$ m, $(v_x)_f = 46$ m/s, and $m = 0.145$ kg. Assume $(v_x)_i = 0.0$ m/s.

We'll first solve for a_x and then use Newton's second law to find the average force.

Solve: (a)



(b) Solve the equation for a_x .

$$a_x = \frac{(v_x)_f^2 - (v_x)_i^2}{2\Delta x} = \frac{(46 \text{ m/s})^2 - (0.0 \text{ m/s})^2}{2(1.0 \text{ m})} = 1060 \text{ m/s}^2$$

$$F_x = ma_x = (0.145 \text{ kg})(1060 \text{ m/s}^2) = 150 \text{ N}$$

(c) Say a typical pitcher weighs 170 lbs.

$$170 \text{ lb} \left(\frac{4.45 \text{ N}}{1 \text{ lb}} \right) \approx 760 \text{ N}$$

Now divide the force from part (b) by this weight to see the fraction.

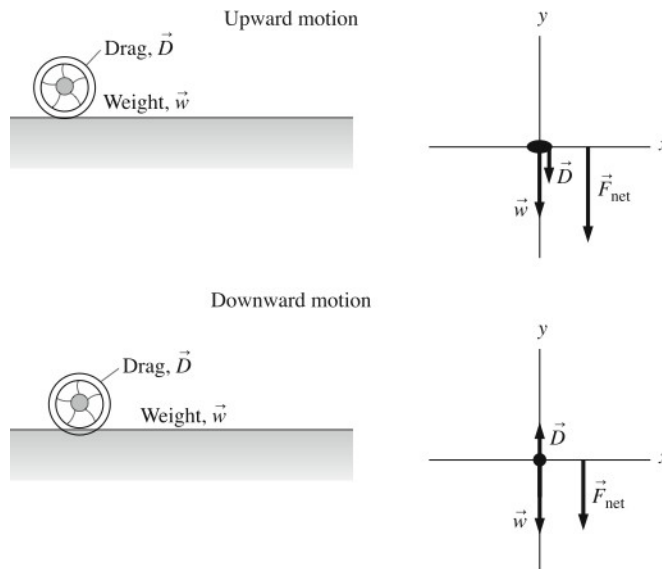
$$150 \text{ N} \div 760 \text{ N} \approx \frac{1}{5}$$

So the force the pitcher exerted on the ball is about 1/5 his weight.

Assess: The answer to each part seems reasonable. The units also work out.

P4.68. Prepare: We will identify all forces on the beach ball and draw a free-body diagram to consider the magnitude of the net force on the ball.

Solve: The beach ball is our system. See the diagram below.



The only contact force is the force of air drag on the ball. The only long-range force is the weight of the ball. Drag always points in the direction opposite to the motion. From the free-body diagram, the net force will always be greater when the beach ball is moving upward compared to downward. There the weight of the ball and the drag force always reinforce each other.

Assess: Note that in the downward portion there is a possibility of the net force equaling zero. The ball will not accelerate downward and fall with constant velocity if this happens, in contrast to the case where there is no drag.