Conceptual Physics/ PEP Name: ____________________ Date: _________

Chapter 5 – The Force Vector

Section Review 5.1

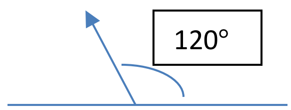
1. Indicate whether each of the following units of measurement are scalar or vector units:

Speed _*scalar*________ time __*scalar*____ mass ___*scalar*___

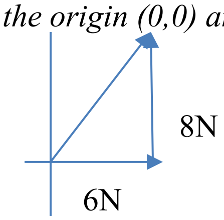
Weight __*vector*______ velocity __*vector*___ temperature __*scalar*___

2. Draw a scaled diagram of a vector that represents a force of 200 N at 120°.

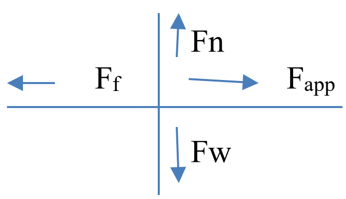
1 cm = 100N (line should be 2 cm long)



3. Draw the force vector (6, 8) N. Is this the same as the force vector (100 N, 53°)? Explain.
A force vector (6,8) N starts at the origin (0,0) and ends at the point 6,8. The resultant of (6,8) is ***10N*** *at approximately 53°.*



4. A box is being pushed across a carpeted floor. Draw a free-body diagram for the box.



Section Review 5.2

1. What is true about the net force acting on an object in equilibrium? What is true about the acceleration of an object in equilibrium?
Both the net force and the acceleration of an object in equilibrium are zero.

2. Study Figure 5.9 on page 112. Suppose the person pulling to the left only exerts 50 N of force, while everything else stays the same. What would be the x- and y- components of the third force, if the forces on the polar bear are to keep it at equilibrium?
(50N, 100N). The third person would need to pull 50N to right and 100N "upward" to equalize the other two forces.

3. What is a *normal* force? And why is it called that?
A normal force is the force exerted by a supporting surface perpendicular to the surface. In mathematics, normal means perpendicular.

4. How does Newton's third law explain the existence of normal forces?
Newton's 3rd law deals with action-reaction pairs. The book exerts a contact force (action) on the table, and the table exerts a normal force (reaction) on the book.

5. The spring in a scale stretches 1 centimeter when a 5-newton object hangs from it. How much does an object weigh if it stretches the spring 2 centimeters?
If 1 cm stretch results from 5N of force, then a 2 cm stretch will result from a force of 10N.

Section Review 5.3
1. Explain the causes of sliding friction and static friction. How are they different?
Sliding friction exists when two objects or surfaces slide across each other. Sliding friction is the resistance created by the sliding motion. Static friction occurs when forces are acting upon an object to make it move, but friction is keeping the object from moving. With static friction, no motion occurs.

2. What do you know about the friction force on an object pulled at a constant speed?
The friction force exerted on an object moving at a constant speed is ***equal*** *to the applied force used to maintain the constant speed. The force from friction is equal and opposite to the applied force, resulting in zero net force, and zero acceleration (thus, a constant speed).*

3. What factors affect the friction force between two surfaces?
Factors affecting the friction force include
- *the nature of the two surfaces (smooth, rough, etc)*
- *the forces pushing the two surfaces together (e.g. weight of object resting on other)*
- *the type of friction measured (static or sliding).*

4. Provide an example of friction that is useful and one that is not useful. Use examples not mentioned in the book.
Answers will vary.
In winter, sand s-prinked on ice would enable a person to walk more easily across the ice (useful), but the sand would make it more difficult to ice skate (not useful).

Section Review 5.4
1. List two ways in which torque is different from force.

a. *Torque is a measure of how much a force acting on an object causes the object to rotate. Torque tends to produce rotation while applied force tends to create straight line motion. Force is a push and pull; Torque is a twist.*

b. *While the net force applied to an object may be zero and the object is in force equilibrium, the object is not necessarily in rotational equilibrium.*

2. In what units is torque measured?
Torque is measured in Newtons-meters.

3. Explain how the same force can create different amounts of torque on an object.
The amount of torque created by a force depends on the distance from the axis of rotation at which the force is applied. Force applied farther from the axis of rotation creates more torque.

4. What is the net torque on an object in rotational equilibrium?
The net torque of an object in rotational equilibrium is zero.

5. A boy and a cat sit on a seesaw as shown in Figure 5.30 on page 125. Use the information in the picture to calculate the torque created by the cat. Then, calculate the boy's distance from the center of the seesaw.

$T_{cat} = F\,r = (50N)\,(2m) = 100\ N\text{-}m$

$T_{boy} = T_{cat} = 100\ N\text{-}m$

$T_{boy} = F\,r = (500N)\,(r) = 100\ N\text{-}m$

500N * r = 100N-m, so r = 0.2 m

Chapter 5 Review

Understanding Vocabulary

Select the correct term to complete the sentences.

1. The expression of a person's age as 15 years is an example of a(n) __scalar__ quantity.

2. The sum of the squares of the two _components of a force vector equals the square of the force vector.

Use the illustration on page 128 to answer questions 3 – 6.

3. The illustration of forces acting on an automobile is an example of a(n) _free-body_ diagram.

4. Because the automobile in the illustration is not accelerating, the four forces acting on it are in ___equilibrium_.

5. The force labeled $F_{Ground\text{-}on\text{-}car}$ could be labeled F_n and called the ___normal_ force.

6. The __resultant____ of the four forces in the illustration is zero.

7. If a carton is pushed at a constant speed along a level floor, the force directly opposing the motion is ___sliding__ friction.

8. The pin in a hinge on a door represents the __axis of rotation__ of the door.

9. A balanced see-saw and a bicycle wheel spinning at a constant speed are examples of __rotational equilibrium__.

Reviewing Concepts

Section 5.1

1. Provide two examples of vector quantities and two examples of scalar quantities.

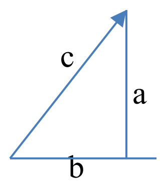
Vector:	force, *weight, velocity*.
Scalar	*speed, time, distance, mass, temperature*

2. List the three different ways in which a force vector can be described.

a. *a graph* b. *a magnitude and angle* c. *an (x,y) pair*

3. Explain how to find the components of a vector.
To find the components of a vector using a graph, first draw the vector to scale and at the correct angle. Then, extend lines parallel to the x and y axes to determine the x and y components of the ending point of the vector.

4. Explain the Pythagorean theorem using an equation and a picture.
The sum of the squares of the sides of a right triangle equals the square of the hypotenuse:
$a^2 + b^2 = c^2$



y-component

x-component

5. A 200-N television sits on a table. Draw a free-body diagram showing the two forces acting on the television.

Normal force = 200N

Weight = 200N

Section 5.2
6. What is the net force on an object in equilibrium?
Zero

7. What is the mathematical meaning of the word *normal*?
The word normal means perpendicular.

8. As you sit on a chair, gravity exerts a downward force on you.

a. What other force acts on you? *The normal force of the chair on me.*

b. What is the direction of this other force?
The normal force is directed straight up (or opposite to gravity).

c. What do you know about the magnitude or strength of this other force?
The magnitude of the normal force is equal to the magnitude of the force of gravity.

9. If an object is in equilibrium, the forces in the x direction must add to ___zero__, and the forces in the y direction must add to ____zero___.

10. You pull one end of a spring to the right.

a. What is the action force? *The force my hand exerts on the spring to the right*

b. What is the reaction force? *The force the spring exerts on my hand to the left*

c. How do the directions of the two forces compare?
The action and reaction forces are opposite in direction.

d. How do the strengths of the two forces compare?
The action and reaction forces are the same in strength.

11. What happens to a spring's force as you stretch it?
The force increases as the spring is stretched.

12. What do you know about a spring if it has a large spring constant?
The spring constant of a spring is the relationship between the force exerted by the spring and its change in length. A large spring constant means the spring is hard to stretch or compress, and therefore it requires a lot of force to change its length. Similarly, it exerts strong forces when its length changes.

Section 5.3

13. List four types of friction.

a. *Static friction*	b. *sliding friction*
c. *rolling friction*	d. *air friction*

14. In which direction does friction act?
Friction acting on a surface always acts opposite to the movement of the surface. Friction is a resistive force.

15. What is the difference between static friction and sliding (dynamic) friction?
Static friction exists between two objects that are stationary; Sliding, or dynamic, friction exists between two surfaces that are sliding across each other.

16. What causes friction?
Friction is caused by the contact between the microscopic hills and valleys on the surfaces of two objects that are interacting.

17. Why is it easier to slide a cardboard box when it is empty compared to when it is full?
A box filled with books has a greater weight, and thus higher force on the floor. The greater the force squeezing two surfaces together, the greater the friction force.

18. Explain the two ways friction can be reduced.

a. *lubricants*

b. *ball bearings (for rotating objects)*

19. Is friction something we always want to reduce? Explain.

There are times when we want to increase the amount of friction. For example, the brakes on a bicycle create friction between the brake pads and the rim of the wheel allowing a rider to slow down.

Section 5.4

20. How are torque and force similar? How are they different?

Torque and force are similar in that torque is created by force. They are different in that torque depends on both force and distance. Forces are pushes and pulls; Torques are twists.

21. Which two quantities determine the torque on an object?

a. Size of force acting on object

b. the length of the lever arm

22. In what units is torque measured? Do these units have the same meaning as they do when measuring work? Explain.

Torque is measured in newton-meters. The newton-meter used for torque is not the same as the newton-meter for work and is not equal to a joule. The object with a torque applied to it does not move in the direction of the force, and therefore no work is done on it.

23. Why is it easier to loosen a bolt with a long-handled wrench than with a short-handled one?

A certain amount of torque is required to loosen a bolt. Since the amount of torque depends on both the strength of the force and the lever arm, a long handled wrench will create more torque compared to a short handled wrench, given the same amount of force applied. Torque = Force times the distance from the axis of rotation.

24. In which of the following cases would a force cause the greatest torque on the shovel? Why?

a. You press straight down on the shovel so it stays straight up and down.

b. You twist the shovel like a screwdriver.

c. You push to the right on the shovel's handle so it tilts towards the ground.

This creates the longest lever arm, or perpendicular distance between the line of action of the force and the axis of rotation.

25. What does it mean to say an object is in rotational equilibrium?

An object is in rotational equilibrium when the net torque applied to it is zero.

Solving Problems

Section 5.1

1. Use a ruler to draw each of the following vectors with a scale of 1 cm = 1 N.

a. (5 N, 0°)	b. (7 N, 45°)
c. (3 N, 90°)	d. (6 N, 30°)

2. Use a ruler to draw each of the following vectors. State the scale you use for each.

a. (40 N, 0°)	b. (20 N, 60°)
c. (100 N, 75°)	d. (500 N, 90°)

3. Use a scaled drawing to find the components of each of the following vectors. State the scale you use for each.

(3.5, 3.5)	(6.9, 4)
a. (5 N, 45°)	b. (8 N, 30°)
(4, 6.9)	(94, 34)
c. (8 N, 60°)	d. (100 N, 20°)

Section 5.2

4. Find the net force on each box in the figure on page 129.

a. *40N to left* b. *25N up* c. *100N, 36°*

5. A 20-kg monkey hangs from a tree limb by both arms. Draw a free-body diagram showing the forces on the monkey (Hint: Twenty kilograms is not a force!)

Using F = ma, the total force is 196N (20 kg x 9.8 m/s). Since the monkey is hanging by both arms, his weight is split with 98N upward force on each arm, and a downward 196N force on the tree limb.

6. An 80-lb bag of cement is contained in a 5-lb bucket supported by a rope. Draw a free-body diagram to represent all the forces applied to the bucket. What is the tension in the rope?

The total weight of the bucket with the cement is 85 lbs, thus total force is 85 lbs. The tension on the rope would also be 85 lbs.

7. A spring has a spring constant of 100 N/m. What forces does the spring exert on you if you stretch it 0.5 m?

Using $F_{spring} = -k\,x$*, the force will be -100N/m x 0.5m = -50 N.*

8. If you stretch a spring 3 cm, it exerts a force of 50 N on your hand. What force will it exert if you stretch it 6 cm?

Stretching the spring twice the length will double the force. So, 100N.

Section 5.3

9. Your backpack weighs 50 N. You pull it across a table at a constant speed by exerting a force of 20 N to the right. Draw a free-body diagram showing all of the forces on it. State the strength of each.

Downward gravity force (weight) of 50N and upward Normal force of 50N;
Rightward applied force of 20N and leftward sliding force of 20N

10. You exert a 50-N force to the right on a 300-N box but it does not move. Draw a free-body diagram for the box. Label all the forces and state their strengths.

Downward gravity force (weight) of 300N and upward Normal force of 300N;
Rightward applied force of 50N and leftward static force of 50N

Section 5.4

11. You push down on a lever with a force of 30 newtons at a distance of 2 m from its fulcrum. What is the torque on the lever?

Torque = $\tau = F\,r$ *= (30N) (2m) = 60 N-m*

12. You use a wrench to loosen a bolt. It finally turns when you apply 300 N of force at a distance of 0.2 m from the center of the bolt. What torque did you apply?

Torque = $\tau = F\,r$ *= (300N) (0.2m) = 60 N-m*

13. A rusty bolt requires 200 N•m of torque to loosen it. If you can exert a maximum force of 400 N, how long a wrench do you need?

Torque = $\tau = F\,r$*. Since we need 200N-m of torque, we can solve for the length of the wrench by using*

200N-m = (400N) r
r = 200N-m / 400N = 0.5 meters

14. Look at the figure of the seesaw on page 130. Calculate the net torque on the see-saw.

The left side creates a torque of 20N x 2m, or 40 N-m.
The right side creates a negative torque (clockwise) of 10N x 1.5m, or 15 N-m.
So, the net torque is 25 N-m (counter-clockwise)

15. You and your cousin sit on a seesaw (as pictured in figure on page 130. You sit at 0.5 m from the fulcrum, and your cousin sits 1.5 m from the fulcrum. You weigh 600 N. How much does your cousin weigh?

Since seesaw is at equilibrium, both sides must have the same torque, or zero net torque.
The left side creates a torque of 600N x 0.5m, or 300 N-m.
Since the cousin is 1.5m from fulcrum, she must weigh 300 N-m divided by 1.5m, or ***200N.*** *Thus her torque (clockwise) would be 200N x 1.5m, or 300 N-m.*

Test Practice

Section 5.1

1. An example of a vector quantity is

a. speed. b. time. c. distance. d. force.

2. A force vector of 10 N is represented on a scale drawing by an arrow 5 cm in length. If the x-component is represented by an arrow 3 cm in length the y-component of the force is

a. 2 N. b. 4 N. c. 6 N. d. 8 N.

3. A worker slides a 50-N object to the right at a constant speed across a horizontal surface using a force of 200 N. Which free body diagram on page 130 best represents the forces acting on the object?

a. b. c. d.

Section 5.2

4. The diagram on page 131 represents two forces acting at point P. Which choice would create a condition of equilibrium with the forces shown?

a. b. c. d.

5. Which pair of forces acting on the same point could produce a resultant of 10 N?

a. 10 N, 10 N b. 10 N, 30 N c. 4.7 N, 4.7 N d. 4.7 N, 5 N

6. A force of 18 N is exerted to stretch a spring 0.3 m. The spring constant for this spring is

a. 0.0167 N/ m. b. 5.4 N/ m. c. 6 N/ m. d. 60 N/ m.

Section 5.3

7. The force exerted on you by the floor as you stand in place is the

a. gravitational force. b. mass.

c. normal force. d. weight.

8. Block A in figure on page 131 is pulled at a constant velocity up an incline as shown. Toward which point will the force of friction be directed?

a. b. c. d.

9. Which type of friction is most closely associated with a lack of motion?

a. sliding friction b. air friction

c. static friction d. rolling friction

10. To overcome sliding friction and keep an object sliding on a level surface, a 100-N force is used. The magnitude of the force needed to start the object sliding

a. is less than 100 N. b. equals 100 N.

c. is more than 100 N. d. cannot be calculated with the information given.

Section 5.4

11. The diagram on page 131 at the right shows two forces applied to a lever. The net torque applied to the lever is

a. +30 N•m. b. +60 N•m. c. -60 N•m. d. 0 N•m.