Test Review № 3

Forces. A force is a push or a pull. Forces are measured in Newtons (*N*) in the metric system. More than one force can act on an object at a time. The net force is the combination of all the forces acting on an object. For forces acting in the same direction, the net force is the sum of the forces. For forces acting in opposite directions the net force is the difference between of the forces. If the forces are equal and opposite, the net force is zero. Forces acting at right angles form a net or *resultant* force that is the hypotenuse of a right triangle with the two forces as the sides. The size of the force can be determined by the Pythagorean theorem ($a^2 + b^2 = c^2$).

Sample Problems:

Problem 1

What is the resultant force on an object when it is acted on by three forces; 2 *N* east, 5 *N* west, and 4 *N* east.

Step 1: Add the forces that are acting in the same direction.
2 *N* east + 4 *N* east = 6 *N* east

Step 2: Subtract the forces that are in the opposite direction. (*NOTE:* The net force is in the direction of the larger force.)
6 *N* east – 5 *N* west = 1 *N* east

Problem 2

What is the net force on an object when it is acted on by a force of 1.5 *N* east and 2 *N* south.

Step 1: Apply the Pythagorean theorem
$c^2 = (1.5)^2 + (2)^2 = 2.25 + 4 = 6.25$

Step 2: Find the square root
$c = \sqrt{c^2} = \sqrt{6.25} = 2.5\ N\ southeast$

Newton's First Law of Motion. According to Newton's First Law of Motion, if the net force on an object is zero, it maintains its state of motion. This means an object in motion will remain in motion at the same speed and in the same direction, while an object at rest will remain at rest. People did not always realize this. Since moving objects eventually come to a stop, people thought the natural state for an object was to be at rest. In order to be in motion, people thought an object had to have a force applied to it. This is because they did not know about friction. A force only needs to be applied to keep a moving object in motion in order to overcome friction.

Friction. Friction is a force that acts to resist sliding between touching surfaces. There are three main types: Static friction – the force that prevents an object at rest from moving when a force is applied; Sliding friction – the force that resists the movement of one surface past another (usually less than static friction); and Rolling friction – friction that results when an object rolls across a surface (usually less than sliding friction). Friction is caused by molecular adhesion, surface roughness, and the plowing effect. Molecular adhesion is a force of attraction between molecules resulting when two materials are brought into close contact with each other. Greater surface roughness increases friction, especially when the materials are rough enough to cause serious abrasion. The plowing effect results when one or more of the materials is relatively soft, and becomes deformed, getting in the way of movement. The heavier an object is, the harder it is to slide. On a flat surface the downward force of the weight is perpendicular to the surface. The component of the weight that is perpendicular to the contact surface is called the normal force. On a flat surface, the weight is the normal force. The force needed to overcome friction (F_f) divided by the normal force (F_N) gives a property of the surfaces known as the coefficient of friction (μ). This means the force needed to slide an objects over each other on a horizontal surface is:

$$\mathbf{F_f = F_N \times \mu}$$

Sample Problems

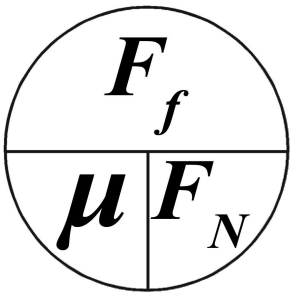
A cross country skier who weighs 800.0 N, waxes his skis and pushes off on the snow.

a. If the coefficient of static friction between the skis and the snow is 0.14, what force is needed to get going?

$$F_f = (800.0N)(0.14) = 112N$$

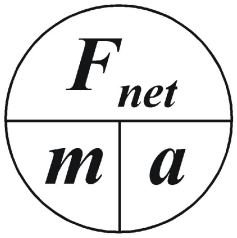
b. If the force is needed to keep moving at constant speed on level ground is 40.0 N, what is the coefficient of sliding friction?

$$\mu = \frac{40.0N}{800.0N} = 0.05$$



Newton's Second Law of Motion. Newton's first law of motion says an object's state of motion will not change unless an unbalanced force is applied to it. This implies that if an unbalanced force *is* applied to an object, its state of motion *will* change. Any change in motion is acceleration. So, force causes acceleration. Now imagine, the same force is used to toss a softball into the air and to toss a bowling ball into the air. Which one will accelerate more? The one with the smaller mass accelerates more. This is essentially Newton's Second Law. Newton's Second Law of Motion says the acceleration of an object is equal to the net force divided by the mass.

$$acceleration = \frac{net\ \ force}{mass}$$



Any of the three variables, force (F_{net}), mass (m), or acceleration (a), can be determined if the other two variables are known. Since the acceleration due to gravity is a constant 9.8 $^{m}/_{s2}$, the weight of an object, which is the downward force of gravity on the object, can be calculated using the same formula if the mass is known. The units of force are newtons (N), where 1 N = 1 $^{kg \cdot m}/_{s2}$.

Sample Problem 1

What is the acceleration of a 15 kg object that is pushed with a net force of 300. N?

$$a = \frac{F}{m} = \frac{300N}{15kg} = \frac{300.^{kg \cdot m/s^2}}{15kg} = 20.^{m}/_{s^2}$$

Sample Problem 2

What is the weight of a 65 kg object?

$$F = ma = (65kg)(9.8^{m}/_{s^2}) =$$

$$637^{kg \cdot m}/_{s^2} = 637N$$

Sample Problem 3

What is the mass of an object that weighs 441 N?

$$m = \frac{F}{a} = \frac{425N}{9.8^{m}/_{s^2}} = \frac{441^{kg \cdot m/s^2}}{9.8^{m}/_{s^2}} = 45kg$$

Changing Motion and Turning. According to Newton's First Law, an object in motion continues moving in a straight line unless it is acted on by a force. Planets orbit the sun in an almost circular path. They are not violating Newton's First Law. They are obeying Newton's Second Law. The sun is exerting a force on the planets that keeps them revolving.

Force and acceleration are directional. A net force opposite an object's motion is negative and produces a negative acceleration, slowing the object down. A net force in the same direction as an object's motion is positive and produces a positive acceleration, speeding the object up. A net force at an angle to an object's motion will cause the object to change direction. If a force is maintained on an object at an angle to it's motion, it will cause it to follow a curved path or turn. When an unbalanced force is applied to an object at right angles to the object's motion the object travels in a circle. Such a force is called a centripetal force. A centripetal force is toward the center of the object's circular path. This is what keeps planets moving around the sun.

Air Resistance. Air resistance can benefit us, or it can get in the way. Either way, it is a fact of life. When an object passes through air, the air particles need to move out of the way for the object to pass. Air pushing against the moving object produces resistance or **drag**. Normally, the effect of air resistance is so small that we don't notice it. The faster the object moves, however, the greater the resistance is. Stick your hand out the window of a moving car, and you'll feel the resistance. This resistance costs motorists time and money. An object falling through the air speeds up because of gravity. This increases the air resistance. When the air resistance equals the gravitational pull, the net force is zero, and the object stops accelerating. Then the object falls at a constant speed called **terminal velocity**. The acceleration due to gravity is the same for all objects, but air resistance is not. A falling leaf floats slowly through the air. This is because its large surface interacts with a large number of air molecules. Parachute jumpers depend on this to land safely.

If the force of the air resistance on a falling object is known, the affect on its acceleration can be determined.

Sample Problem

What is the acceleration of a 2.0 kg object falling through air if the air resistance is 3.0 N?

Step 1: Determine the weight of the object

$$F = ma = (2.0kg)(9.8^{m}/_{s^2}) = 19.6N$$

Step 2: Determine the net force on the object

$$F_{net} = F_{weight} - F_{air\ resistance} = 19.6N - 3.0N = 16.6N$$

Step 3: Determine the acceleration

$$a = \frac{F_{net}}{m} = \frac{16.6N}{2.0kg} = 8.3^{m}/_{s^2}$$

Center of Mass. Objects don't have their mass distributed evenly. Archimedes, an ancient Greek mathematician, showed that the effect on rigid bar by weights resting at various points along it is the same as it would be if all the weights were moved to a single point. This point is called the **center of mass** or the **center of gravity**. If you try to balance an object, it will only balance over its center of mass. If the center of mass is not over the base, the object will fall. The center of mass of a system of particles is a specific point at which the system's mass behaves as if it were concentrated. In the case of a rigid body, its position is fixed in relation to the object (but not necessarily in contact with it). The geometric center of an object is not necessarily its center of mass. It is easiest to interpret the way an object responds to forces by looking at the behavior of the center of mass. This makes it a very significant point to engineers. Engineers try to design a sports car so its center of gravity is as low as possible to make the car handle better. For a plane to be safe to fly, the center of gravity should be about one quarter of the way from the wing leading edge to the wing trailing edge.

Answer the questions below by circling the number of the correct response

1. A body builder bench presses a 980 N barbell with an upward force of 1050 N. What is the net force on the barbell? (1) 70 N up (2) 70 N down (3) 2030 N up (4) 2030 N down

2. Two football players grab hold of a football. One pulls the ball north with a force of 600 N. The other pulls the ball east with a force of 800 N. What is the net force on the football? (1) 1400 N east (2) 200 N north (3) 1,000 N northeast (4) 480,000 N northeast

3. Two workers push on a crate, one with a force of 550 N east, and the other with a force of 720 N east. The crate is held in place by a spring that pulls west with a force of 930 N. What is the net force on the crate? (1) 2,150 N west (2) 340 N east (3) 1,100 N west (4) 760 N east

4. What is the net force on an object that is traveling in a straight line at a constant speed of 50 m/s? (1) 0 N (2) 50 N (3) 5 N (4) 500 N

5. What force is needed to start skating by a 550.0 N ice skater if the coefficient of static friction between the blades of her skates and the ice is 0.03? (1) 16.5 N (2) 18,333 N (3) 550.03 N (4) 5.45×10^{-5} N

6. What is the weight of a car if the coefficient of static friction between the tires and the road is 0.72, and the force needed to get going is 10,800 N? (1) 7,776 N (2) 15,000 N (3) 10,800.72 N (4) 6.67×10^{-5} N

7. What is the coefficient of sliding friction between a toboggan and wet snow if a 2,050 N push is needed to keep 20,500 N toboggan and its occupants moving at constant speed? (1) 18,450 (2) 10 (3) 0.10 (4) 42,025,000

8. A force of 30 N east is needed to slide a box at a constant speed. What is the force of friction on the box? (1) 0 N (2) 30 N east (3) 30 N west (4) There is not enough information to tell.

9. What is the mass of an object that accelerates at 20.0 m/s^2 as a result of a 15 N force? (1) 1.33 kg (2) 35 kg (3) 0.75 kg (4) 5 kg

10. What is the acceleration of a 45 kg object that is pushed with a net force of 630. N? (1) 14 m/s^2 (2) 7.14 m/s^2 (3) 28,350 m/s^2 (4) 675 m/s^2

11. What is the net force required to accelerate a 24 kg object at 18 m/s^2? (1) 1.33 N (2) 0.75 N (3) 42 N (4) 432 N

12. What is the acceleration of an 81 kg object that is pushed with a net force of 243 N? (1) 0.33 m/s^2 (2) 324 m/s^2 (3) 3 m/s^2 (4) 162 m/s^2

13. What is the mass of an object that weighs 196 N? (1) 0.05 kg (2) 20 kg (3) 1,921 kg (4) 196 kg.

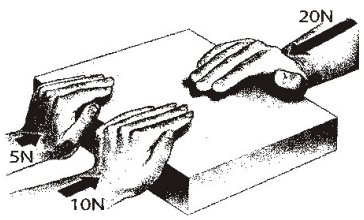
14. What is the weight of a 27 kg mass? (1) 0.36 N (2) 265 N (3) 2.8 N (4) 27 N

15. What is the acceleration of a 15 kg object falling through air if the air resistance is 42 N? (1) 7 m/s^2 (2) 57 m/s^2 (3) 27 m/s^2 (4) 9.4 m/s^2

16. Which of the following changes when an unbalanced force acts on an object? (1) mass (2) motion (3) inertia (4) weight

17. Which of the following is the force that slows a book sliding on a table? (1) gravity (2) static friction (3) sliding friction (4) inertia

18. Two students are pushing on the left side of a box and one student is pushing on the right. The diagram below shows the forces they exert. Which way will the box move? (1) up (2) left (3) down (4) right



19. What combination of units is equivalent to the newton? (1) m/s^2 (2) kg-m/s (3) kg-m/s^2 (4) kg/m

20. Which of the following is a push or a pull? (1) force (2) momentum (3) acceleration (4) inertia

21. An object is accelerated by a net force in which direction? (1) at an angle to the force (2) in the direction of the force (3) in the direction opposite to the force (4) Any of these is possible.

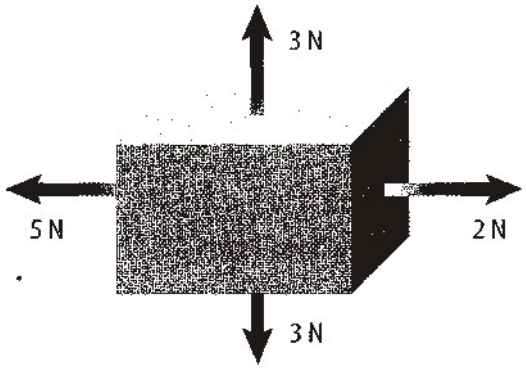
22. You are riding on a bike. In which of the following situations are the forces acting on the bike balanced? (1) You pedal to speed up. (2) You turn at constant speed. (3) You coast to slow down. (4) You pedal at constant speed.

23. Which of the following has no direction? (1) force (2) acceleration (3) weight (4) mass

24. Why does the speed of a sled increase as it moves down a snow-covered hill, even though no one is pushing on the sled. (1) due to friction (2) due to inertia (2) due to momentum (4) due to gravity

25. Two balls of the same size and shape are dropped from a helicopter. One ball has twice the mass of the other ball. On which ball will the force of air resistance be greater when terminal velocity is reached? (1) the heavier one (2) the lighter on (3) they will both be the same.

26. What is the net force on the box pictured below?



(1) 3 N up (2) 7 N left (3) 3 N left (4) 6 N down

27. Which of the following descriptions of gravitational force is *not* true? (1) It depends on the mass of objects. (2) It is a repulsive force. (3) It depends on the distance between objects. (4) It exists between all objects.

28. What is the weight of a book that has a mass of 0.35 kg? (1) 0.036 N (2) 3.4 N (3) 28 N (4) 34 N

29. If you swing an object on the end of a string around in a circle, the string pulls on the object to keep it moving in a circle. What is the name of this force? (1) inertial (2) centripetal (3) resistance (4) gravitational

30. What is the acceleration of a 1.4-kg object if the gravitational force pulls downward on it, but air resistance pushes upward on it with a force of 2.5 N? (1) 11.6 m/s^2, downward (2) 11.6 m/s^2, upward (3) 8.0 m/s^2, downward (4) 8.0 m/s^2, upward

31. A skater is coasting along the ice without exerting any apparent force. Which law of motion explains the skater's ability to continue moving? (1) Newton's First Law (2) Newton's Second Law (3) Newton's Third Law (4) Newton's Fourth Law

32. After a soccer ball is kicked into the air, what force or forces are acting on it? (1) the kick only (2) weight only (3) air resistance only (4) weight and air resistance

33. What is the force on an 8.55-kg object that accelerates at 5.34 m/s^2. (1) 0.62 N (2) 45.7 N (3) 1.60 N (4) 13.89 N

34. An object acted on by a force of 2.8 N has an acceleration of 3.6 m/s^2. What is the mass of the object? (1) 0.78 kg (2) 1.29 kg (3) 10.1 kg (4) 6.4 kg

Use the table below to answer questions 35 and 36.

Mass of Common Objects	
Object	**Mass (g)**
Cup	380
Book	1,100
Can	240
Ruler	25
Stapler	620

35. Which object would have an acceleration of 0.89 m/s^2 if you pushed on it with a force of 0.55 N? (1) book (2) can (3) ruler (4) stapler

36. Which object would have the greatest acceleration if you pushed on it with a force of 8.2 N? (1) can (2) stapler (3) ruler (4) book

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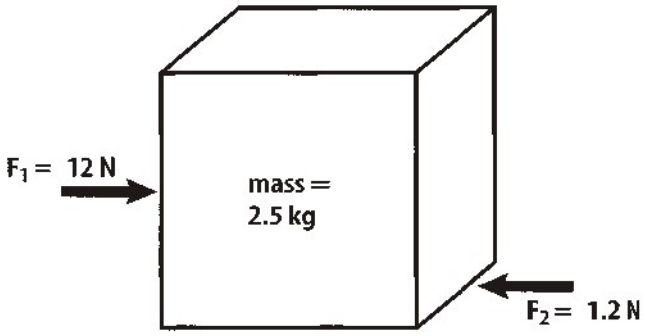
Use the figure below to answer questions 37 and 38.



37. The figure above shows the horizontal forces that act on a box that is pushed from the left with a force of 12 N. What force is resisting the horizontal motion in this illustration? (1) friction (2) gravity (3)inertia (4) momentum

38. What is the acceleration of the box? (1) 27 m/s^2 (2) 4.8 m/s^2 (3) 4.3 m/s^2 (4) 0.48 m/s^2

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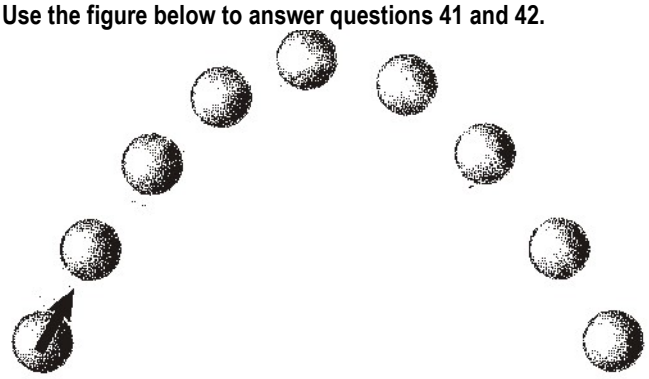
39. What is the acceleration a 1.4-kg object falling through the air if the force of air resistance on the object is 2.5 N? (1) 3.9 m/s^2 (2) 8.0 m/s^2 (3) 9.2 m/s^2 (4) 1.1 m/s^2

40. Two 20.-newton forces act concurrently on an object. What angle between these forces will produce a resultant force with the greatest magnitude? (1) 0° (2) 45° (3) 90.° (4) 180.°

Use the figure below to answer questions 41 and 42.



41. The figure above shows the path a ball thrown into the air follows. What causes the ball to move along a curved path? (1) air resistance (2) gravity acting opposite the direction to the ball's movement (3) gravity acting in the same direction as the ball's movement (4) gravity acting at an angle to the direction to the ball's movement

42. What effect would throwing the ball harder have? (1) The path wouldn't curve. (2) The acceleration of gravity would be larger. (3) The acceleration of gravity would be smaller. (4) The ball would go higher.

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43. A heavy box sits on a sidewalk. If you push against the box, the box moves in the direction of the force. If the box is replaced with a ball of the same mass, and you push with the same force against the ball, how will the acceleration compare? (1) It will be larger. (2) It will be smaller. (3) It will be the same.

44. Bowling pins are hard to knock over because their center of mass is (1) high, (2) low, (3) hard to locate, (4) small.

45. Why are sports cars more stable in quick turns than trucks? (1) Sports cars have a lower center of mass. (2) Sports cars have a higher center of mass. (3) Sports cars have no center of mass. (4) Sports cars have a moveable center of mass.

46. A rock is thrown straight up into the air. At the highest point of the rock's path, the magnitude of the net force acting on the rock is (1) less than the magnitude of the rock's weight, but greater than zero, (2) greater than the magnitude of the rock's weight, (3) the same as the magnitude of the rock's weight, (4) zero.

Answers

1. 1	13. 2	25. 1	37. 1
2. 3	14. 2	26. 3	38. 3
3. 2	15. 1	27. 2	39. 2
4. 1	16. 2	28. 2	40. 1
5. 1	17. 3	29. 2	41. 4
6. 2	18. 2	30. 3	42. 4
7. 4	19. 3	31. 1	43. 1
8. 3	20. 1	32. 4	44. 2
9. 3	21. 2	33. 2	45. 1
10. 1	22. 4	34. 1	46. 3
11. 4	23. 4	35. 4	
12. 3	24. 4	36. 3	