**Forces in Two Dimensions**

**Question 1:**

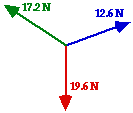
aa. A sign that weighs 40 N is supported symmetrically by two cables that make an angle of 60.5 degrees with the horizontal. A single cable will pull upward on the sign with a force of \_\_\_\_ Newton.

a. 17.4 b. 20.0 c. 30.3 d. 34.8

e. 40.0 ab. 69.6 ac. 80.0 ad. 121.0

ae. ... nonsense! The answer cannot be determined without knowing the actual tension in a single cable.

**Question 2:**

aa. Object A is at equilibrium. The diagram at the right shows the values of the only three forces which act upon object A. The vector sum of these three forces is \_\_\_\_\_ Newtons.

a. 0 b. 10.2 c. 19.6

d. 29.8 e. 49.4

ab. ... nonsense! It is impossible to tell without knowledge of directions.

**Question 3:**

aa. An **equilibrant** is defined as \_\_\_\_.

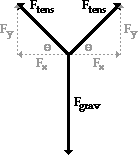
a. the weight of an object

b. a force which puts an object at equilibrium

c. the inertial force required to keep an object moving

d. the net force experienced by an object which is at equilibrium

**Question 4:**

aa. A sign with a mass of **m** is hung symmetrically from two cables which make an angle of **theta** with the horizontal (see diagram). The tension in each one of the cables is **Ftens**. The vertical component of the tension force is **Fy**; the horizontal component is **Fx**. Which of the following mathematical statements are true? (Statements are comparing the magnitudes only; not the directions.) Select all that apply.

a. Fy = m b. Fy = m • g

c. Fgrav = 2 • m d. Fy = 0.5 • m

e. Fnet = m • g ab. Fnet = 2 • Ftens

ac. Fgrav = Fy + Fy ad. Fy = 0.5 • m • g

ae. Fgrav = 2 • m • g

**Questions 5-7:**

A skier is sliding down a slope.

aa. The gravitational force acting upon the skier is directed \_\_\_\_\_.

a. straight upward b. parallel to the slope

c. straight downward d. perpendicular to the slope

aa. The normal force acting upon the skier is directed \_\_\_\_\_.

a. straight upward b. parallel to the slope

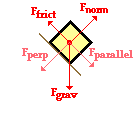
c. straight downward d. perpendicular to the slope

aa. The friction force acting upon the skier is directed \_\_\_\_\_.

a. straight upward b. parallel to the slope

c. straight downward d. perpendicular to the slope

**Question 8:**

 (Note: the diagram at the right is not drawn to scale.)

aa. An object of mass *m* is resting upon an inclined plane with an incline angle of *theta*. The coefficient of friction between the object and the plane is *mu*. The object is at rest upon the incline. The free-body diagram is shown with the weight vector resolved into parallel and perpendicular components. Which of the following mathematical statements are correct? Select all that apply.

a. Fnorm = Ffrict b. Fnorm = Fgrav

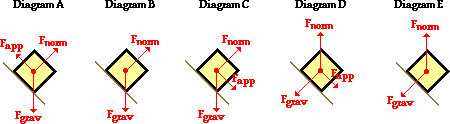
c. Fnet = Fparallel d. Fparallel = Ffrict

e. Fperpendicular = Fnorm f. Ffrict = mu • Fnorm

g. Fperpendicular = Fgrav

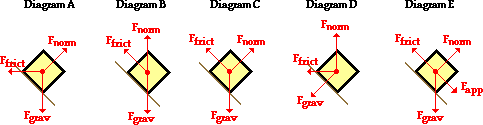
**Question 9:**

aa. An object upon an inclined plane is accelerating down the incline. Friction is absent. Which one of the following diagrams represent the free-body diagram for such an object? Observe all force labels carefully.

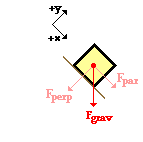


**Question 10:**

aa. An object upon an inclined plane is accelerating down the incline. Friction is present. Which one of the following diagrams represent the free-body diagram for such an object? Observe all force labels carefully.



**Question 11:**

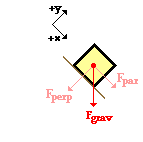
aa. Consider the diagram at the right of a crate placed upon the inclined plane. The gravity force is the only force shown; other forces are surely present. The +x-axis has been defined as parallel and down the incline. The +y-axis is defined as perpendicular to the incline and upward. Consider a situation in which the crate slides down the incline at a constant speed. How does the parallel component of the force of gravity compare to the force of sliding friction?

a. They are equal in magnitude.

b. The force of sliding friction is greater.

c. The parallel component of the gravity force is greater.

**Question 12:**

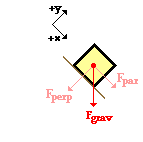
aa. Consider the diagram at the right of a crate placed upon the inclined plane. The gravity force is the only force shown; other forces are surely present. The +x-axis has been defined as parallel and down the incline. The +y-axis is defined as perpendicular to the incline and upward. Consider a situation in which the crate slides down the incline at a constant speed. How does the perpendicular component of the force of gravity compare to the normal force?

a. The normal force is greater.

b. They are equal in magnitude.

c. The perpendicular component of the gravity force is greater.

**Question 13:**

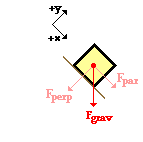
aa. Consider the diagram at the right of a crate placed upon the inclined plane. The gravity force is the only force shown; other forces are surely present. The +x-axis has been defined as parallel and down the incline. The +y-axis is defined as perpendicular to the incline and upward. Consider a situation in which the crate slides down the incline and speeds up. How does the parallel component of the force of gravity compare to the force of sliding friction?

a. They are equal in magnitude.

b. The force of sliding friction is greater.

c. The parallel component of the gravity force is greater.

**Question 14:**

aa. Consider the diagram at the right of a crate placed upon the inclined plane. The gravity force is the only force shown; other forces are surely present. The +x-axis has been defined as parallel and down the incline. The +y-axis is defined as perpendicular to the incline and upward. Consider a situation in which the crate slides down the incline and speeds up. How does the perpendicular component of the force of gravity compare to the normal force?

a. The normal force is greater.

b. They are equal in magnitude.

c. The perpendicular component of the gravity force is greater.

**Question 15:**

aa. An object of mass 'm' is placed upon an inclined plane with an incline angle of *theta*. The surface is rough and there is a coefficient of friction of *mu*. The force of friction acting upon the object is equivalent to \_\_\_\_.

a. mu•g b. mu•m•g c. mu•Fnorm•g d. mu•m•g•sine(theta)

e. mu•m•g•cosine(theta) ab. mu•Fnorm•sine(theta)

ac. mu•m•g•tangent(theta) ad. mu•Fnorm•cosine(theta)

**Calculations and Long Answer Questions**

**Question 16:**

aa. Consider the force vector at the right. The force has an equilibrant that has a magnitude of:

… and a direction of:

**Question 17:**

aa. Consider the diagram at the right. Force **A** has a magnitude of 21 Newton. Force **B** has a magnitude of 46 Newton. What magnitude must a third force (force **C**) have in order to be an equilibrant?

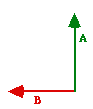
**Question 18:**

aa. Consider the diagram at the right. Force **A** has a magnitude of 32.1 Newton. Force **B** has a magnitude of 56.6 Newton.

a. What magnitude must a third force (force **C**) have in order to be the equilibrant?

b. What direction must force **C** have in order to be the equilibrant?

**Question 19:**

aa. Consider the diagram at the right. Force **A** has a magnitude of 61.6 Newton. Force **B** has a magnitude of 48.3 Newton.

a. What magnitude must a third force (force **C**) have in order to be the equilibrant?

b. What direction must force **C** have in order to be the equilibrant?

**Question 20:**

aa. Consider the force vector at the right. The force vector has an equilibrant that has a magnitude of:

… and a direction of:

**Question 21:**

aa. A student slides a 1390 N crate across the floor by pulling with a force of 804 N at an angle of 32.0 degrees above the horizontal. If the crate moves at a constant speed, find the coefficient of sliding friction between the crate and the floor.

**Question 22:**

aa. A 61.3-kg sign is hanging symmetrically by two cables that make an angle of 31.9 degrees with the horizontal.

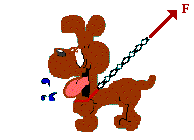
a. How much vertical pull (in Newton) must a single cable supply in order to balance the weight of the sign?

b. Determine the tension (in Newton) in one of the cables.

**Question 23:**

aa. In a physics lab, a sign is hung symmetrically by a light string. The string makes a V-shape due to the downward pull of the sign. The angle between the string (i.e., the angle of the V) is 127 degrees. The tension on each side of the string is 18.8 N. Determine the mass (in kg) of the sign.

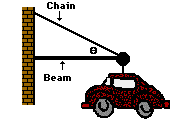
**Question 24:**

aa. A man is attempting to train his dog as shown in the diagram at the right. He is pulling on the dog with a force of 69.7 Newton at an angle of 45.9 degrees above the horizontal.

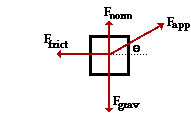
a. Find the x-component of the applied force.

b. Find the y-component of the applied force.

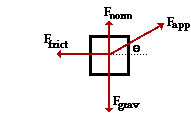
**Question 25:**

aa. An automobile dealership has chosen to hang a car outside the entry to their showroom. The car's mass is 1390 kg. The car's weight will be supported by a heavy-duty chain that pulls upwards and leftwards. A beam will push outward to balance the inward pull of the chain. The manufacturer of the chain claims it has a breaking strength of 43500 Newton. Village code requires that there be a safety factor of 2.53. That is, the actual tension in the chain must be no more than 1/2.53 of the breaking strength. What is the minimum angle (in degrees) at which the dealership can hang the car?

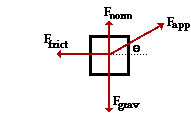
**Question 26:**

aa. Consider the free-body diagram shown at the right. If the applied force is 144 N at an angle of 33.0 degrees, the force of gravity is 145 N and the coefficient of friction is 0.417, then what is the acceleration (in m/s/s) of the object?

**Question 27:**

aa. Consider the free-body diagram shown at the right. If the applied force is 88.4 N at an angle of 23.0 degrees, the force of gravity is 145 N and the coefficient of friction is 0.676, then what is the acceleration (in m/s/s) of the object?

**Question 28:**

aa. Consider the free-body diagram shown at the right. The object's mass is 14.9 kg. An applied force of 70.7 N is exerted at an angle of 31.7 degrees with the horizontal. What coefficient of friction would result in the object moving with a constant velocity of 1.56 m/s?

**Question 29:**

aa. During bookstore sales in August, a box of books weighing 289 N is shoved across the floor by exerting a force of 462 N downward at angle of 25.2 degrees below the horizontal . If the coefficient of kinetic friction is 0.479, how long (in seconds) does it take the box to move 3.91 meters.

**Question 30:**

aa. A man doing his annual cleaning pulls a 141-N vacuum cleaner across the floor at a constant velocity of 1.17 m/s by exerting a force on it at an angle of 34.2 degrees above the horizontal. If he must pull with a force of 34.7 N to move the vacuum cleaner, what is the coefficient of friction between the vacuum cleaner and the floor?

**Question 31:**

aa. In order to determine the coefficients of friction between rubber and various surfaces, a student uses a rubber eraser and an inclined board. In one experiment, the eraser slips down the incline when the angle of inclination is 18.6 degrees, and then moves down the incline with a constant speed when the angle is reduced to 13.5 degrees.

a. Determine the coefficient of static friction for this experiment.

b. Determine the coefficient of kinetic friction for this experiment.

**Question 32:**

aa. A box slides down a 26.8-degree ramp with an acceleration of 1.28 m/s/s. Determine the coefficient of kinetic friction between the box and the ramp.

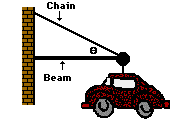
**Question 33:**

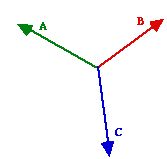
aa, A 30.0-kg sign is hanging symmetrically by two cables which make an angle of 17.6 degrees with the horizontal.

a. How much vertical pull (in Newton) must a single cable supply in order to balance the weight of the sign?

b. Determine the tension (in Newton) in one of the cables.

**Question 34:**

aa. An automobile dealership has chosen to hang a car outside the entry to their showroom. The car's mass is 1110 kg. The car's weight will be supported by a heavy-duty chain which pulls upwards and leftwards. A beam will push outward to balance the inward pull of the chain. The manufacturer of the chain claims it has a breaking strength of 43200 Newton. Village code requires that there be a safety factor of 2.41. That is, the actual tension in the chain must be no more than 1/2.41 of the breaking strength. What is the minimum angle (in degrees) at which the dealership can hang the car?

**Question 35:**

aa. Consider the diagram at the right. Three forces are acting upon a point. Force **A** has a magnitude of 34.1 Newton and a direction of 30 degrees N of W. Force **B** has a magnitude of 35.1 Newton and a direction of 38 degrees N of E.

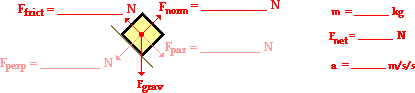
a. What is the magnitude of the sum of vector A and vector B? **HINT:** Resolve A and B into E-W and N-S components and add the parts.

b. What is the direction of force A plus force B?

c. What magnitude and direction must force C have in order for the object to be at equilibrium?

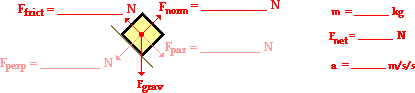
**Question 36:**

aa. Use the diagram below to assist in your problem solving. A 4.01-kg object is placed upon an inclined plane that has an incline angle of 26.9 degrees. The surface is frictionless. Determine the acceleration (in m/s/s) of the object.



**Question 37:**

aa. Use the diagram below to assist in your problem solving. A 4.01-kg object is placed upon an inclined plane which has an incline angle of 26.9 degrees. The object slides down the inclined plane with a constant velocity.



a. What is the force of friction (in Newtons) acting upon the object?

b. Determine the coefficient of friction (mu) for the above surfaces. (Use at least three decimal places.)

**Question 38:**

aa. Use the diagram below to assist in your problem solving. A 24.1-kg object is placed upon an inclined plane that has an incline angle of 56.9 degrees. The coefficient of friction between the surface and the object is 0.301. Determine the acceleration (in m/s/s) of the object.

