Name: ______________________________________ Class: _________ Date: ___________

Sec 3 Physics

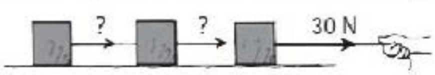
Worksheet 9: Forces and Dynamics

SECTION A: CONCEPTUAL QUESTIONS

1 Can the velocity of an object reverse direction while maintaining a constant acceleration? If so, give an example; if not, explain.

2 Is it possible to move in a curved path in the absence of a force? Defend your answer.

3 Three identical blocks are pulled as shown on a horizontal frictionless surface. If the tension in the rope held by the hand is 30 N, what is the tension in the other ropes?



4 How does the force of gravity on a raindrop compare with the air drag it encounters when it falls at constant velocity?

5 If you hold your book horizontally with a piece of paper beneath it, then drop both. They fall together. Repeat the experiment, but place the paper on *top* of the book. Describe the motion of the paper relative to the book. (Try it and see!)

6 How does the terminal speed of a parachutist before opening a parachute compare to terminal speed after? Why is there a difference?

7 Why is it that a cat that accidentally falls from the top of a 50-storey building hits a safety net below no faster than if it fell from the twentieth storey?

8 Under what conditions would a metal sphere dropping through a viscous liquid be in equilibrium?

9 If Galileo dropped two balls from the top of the Leaning Tower of Pisa, air resistance was not negligible. Assuming that both the balls were of the same size, one made of wood and one of iron, which ball hit the ground first? Why?

10 Free-fall is motion in which gravity is the only force acting.

A Is a skydiver who has reached a terminal speed in free fall?
B Is a satellite above the atmosphere that circles the Earth in free fall?

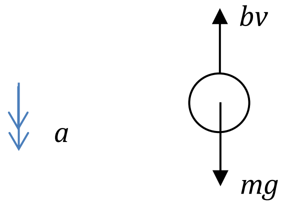
SECTION B: MULTIPLE CHOICE QUESTIONS

1 Three forces act on an object. If the object is in translational equilibrium, which of the following must be true?

I The vector sum of the three forces must equal zero.
II The magnitudes of the three forces must be equal.
III All three forces must be parallel.

A I only
B II only
C I and III only
D II and III only
E I, II, and III

2 A ball falls straight down through the air under the influence of gravity. There is a retarding force F on the ball with magnitude given by $F = bv$, where v is the speed of the ball and b is a positive constant. The magnitude of the acceleration a of the ball at any time is equal to which of the following?

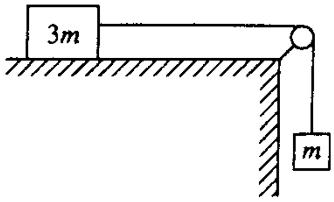


A $g - b$
B $g - \frac{bv}{m}$
C $g + \frac{bv}{m}$
D $\frac{g}{b}$
E $\frac{bv}{m}$

3 An object is released from rest on a planet that has no atmosphere. The object falls freely for 4.0 m in the first two seconds. What is the magnitude of the acceleration due to gravity on the planet?

A $1.0\ \text{m s}^{-2}$
B $2.0\ \text{m s}^{-2}$
C $4.0\ \text{m s}^{-2}$
D $8.0\ \text{m s}^{-2}$
E $12.0\ \text{m s}^{-2}$

4



A block of mass 3*m* can move without friction on a horizontal table. This block is attached to another block of mass *m* by a cord that passes over a frictionless pulley. If the masses of the cord and the pulley are negligible, calculate the magnitude of the acceleration of the descending block *m*?

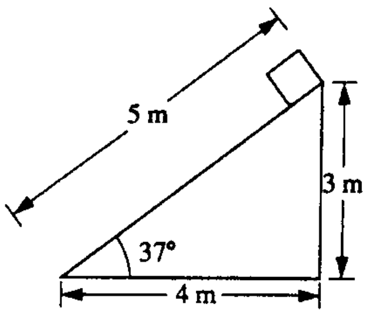
A zero
B *g*/4
C *g*/3
D 2*g*/3
E *g*

5 An astronaut drops an apple on the surface of the Moon. The acceleration due to gravity is 1/6 on Earth. The time it takes for the apple to fall to the ground compared with an apple dropped from the same height on Earth is

A the same
B $\sqrt{6}$ times as long
C 6 times as long
D 36 times as long

The following figure is used in questions **6** and **7**.

6



A plane 5 m in length is inclined at an angle of 37°, as shown above. A block of weight 20 N is placed at the top of the plane and allowed to slide down.

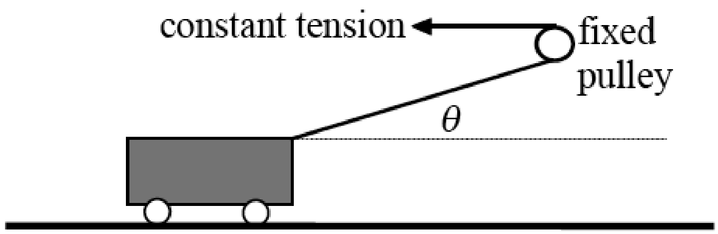
The mass of the block is most nearly

A 1.0 kg
B 1.2 kg
C 1.6 kg
D 2.0 kg
E 2.5 kg

7 The magnitude of the normal force exerted on the block by the plane is most nearly

A 10 N
B 12 N
C 16 N
D 20 N
E 33 N

8 A cart is pulled along a horizontal track by a rope that passes over a fixed pulley.

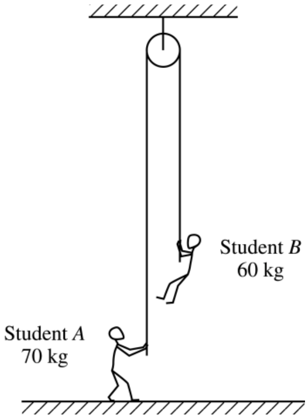


As the cart moves to the right, assume the tension in the rope and the frictional forces on the cart remain constant. As the cart moves to the right, its acceleration

A decreases.
B increases.
C remains constant.
D is zero.

SECTION C: STRUCTURED QUESTIONS

1



A rope of negligible mass passes over a pulley of negligible mass attached to the ceiling. One end of the rope is held by Student *A* of mass 70 kg, who is at rest on the floor. The opposite end of the rope is held by Student B, who has a mass 60 kg and is suspended at rest.

(a) The dots below represent the students. Draw and label free-body diagrams showing the forces on Student *A* and Student *B*.

● *B*

● *A*

(b) Calculate the magnitude of the force exerted by the floor on Student *A*.

Student *B* now climbs up the rope at a constant acceleration of 0.25 m s^{-2} with respect to the floor.

(c) Calculate the tension in the rope while Student *B* is accelerating.

(d) As Student *B* is accelerating, is Student *A* pulled upward off the floor? Justify your answer.

(e) With what minimum acceleration must Student *B* climb up the rope to lift Student *A* upward off the floor?

2 Alicia was standing on a bathroom scale placed in a lift.

(a) The reading on the scales was 720 N when the lift was accelerating upwards at 2 m s^{-2}. Calculate the actual mass of Alicia.

(b) During another part of the journey, the bathroom scales read 450 N. Calculate the acceleration of Alicia at this instance.

(c) The rope of the lift suddenly snaps. Before the safety devices kick in, what would the reading on the bathroom scale be? Explain your answer.

3 Christopher and his 12.0 kg backpack are on the surface of a frozen lake, 20.0 m apart. Christopher exerts a horizontal force of 6.00 N on the backpack using a light rope, pulling it towards him. Assume that there are no frictional forces on the ice and that the mass of Christopher is 80.0 kg. (*Light rope implies that we can ignore the mass of the rope in our calculations.*)

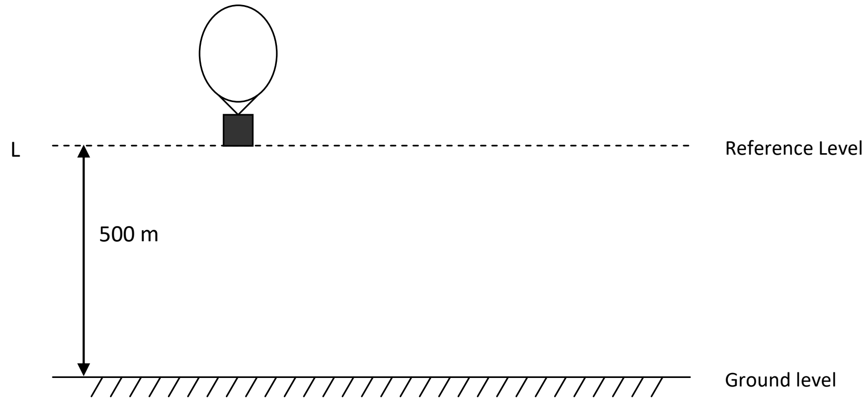
a Draw free-body diagrams to show the forces acting on the backpack and Christopher. Indicate which pair(s) of forces acting on these 2 objects are action-reaction pairs.

B Calculate the acceleration of the backpack.

C Calculate the acceleration of Christopher.

D What is the displacement of Christopher from his initial position do they meet?

4 With a 100 kg basket attached, a hot-air balloon was moving vertically downwards with a constant speed of 10 m s^{-1}. At time t = 0 s, the hot-air balloon reached level *L,* 500 m above the ground. The combined mass of the hot-air balloon with the basket was 3000 kg. Ignore the effects of air resistance.



(a) State the resultant force on the hot-air balloon with the attached basket. Explain how you deduce this value from the information given.

(b) Hence, deduce the upward force acting on the balloon.

(c) At this instance shown above, the basket attached to the hot-air balloon broke free from the rest of the hot-air balloon. Assume that the upward force on the balloon remains constant.

(i) Draw free-body diagrams to show the forces acting on the hot-air balloon and when the basket is detached from the balloon.

(ii) Calculate the time required for the basket to hit the ground.

(iii) Using a carefully sketched velocity-time graph, describe and explain the motion of the hot-air balloon after the basket is detached from it. Indicate all the essential values of velocity and time on the velocity-time graph.

(d) Discuss and explain whether the presence of a constant horizontal wind blowing parallel to the surface of the Earth would affect your answers to **(b)(ii)** and **(b)(iii)** above.

5 A 15.0 kg monkey climbs up one end of a light rope hung over a frictionless tree branch and tied to a 20.0 kg package on the ground on the other end of the rope.

A Calculate the magnitude of the least acceleration the monkey must have if it lifts the package off the ground.

B After the package has been lifted, the monkey stops its climb and holds on to the rope. What are

(i) the tension in the rope and

(ii) the monkey's acceleration?

6 A woman is standing in an elevator holding her 2.5 kg briefcase by its handles.

a Draw a free body diagram for the briefcase if the elevator is accelerating downward at $1.50\ \text{m s}^{-2}$.

b Calculate the downward pull of the briefcase on the woman's arm while the elevator is accelerating.

College Physics, 9th *Ed*, Ch4 Q46

7 A rifle shoots a 4.20 g bullet out of its barrel. The bullet has a muzzle velocity of 965 m s^{-1} just as it leaves the barrel. Assuming a constant horizontal acceleration over a distance of 45.0 cm starting from rest, with no friction between the bullet and the barrel,

(a) what force does the rifle exert on the bullet while it is still in the barrel?

(b) Draw a free-body diagram of the bullet

(i) while it is in the barrel,

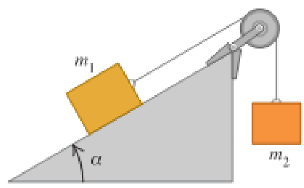
(ii) just after it has left the barrel.

(c) How many g's of acceleration does the rifle give this bullet?

(d) For how long a time is the bullet in the barrel?

College Physics, 9th *Ed*, Ch4 Q48

8 A block with mass m_1 is placed on an inclined plane with a slope angle α and is connected to a second hanging block with mass m_2 by a cord passing over a small, frictionless pulley (see figure right). The coefficient of static friction is μ_s, and the coefficient of kinetic friction is μ_k.



(a) Find the mass m_2 for which the block m_1 moves up the plane at constant speed once it is set in motion.

(b) Find the mass m_2 for which the block m_1 moves down the plane at constant speed once it is set in motion.

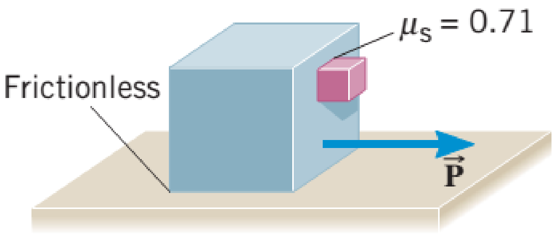
(c) For what range of values of m_2 will the blocks remain at rest if they are released from rest?

College Physics, 9th *Ed*, Ch5 Q78

9 With what terminal speed would a steel ball bearing 2.00 mm in diameter fall in a liquid of viscosity 0.150 $\mathrm{N \cdot s \cdot m^{-2}}$ if we could neglect buoyancy. Assume that the density of steel is $7.8\ \mathrm{g\ cm^{-3}}$.

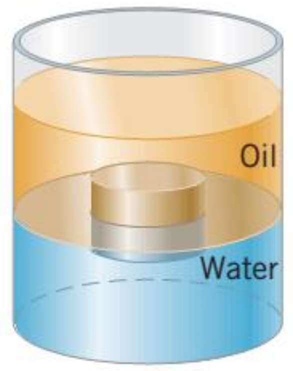
College Physics, 9th *Ed*, Ch13 Q56

10 A large cube (25 kg) is being accelerated across a horizontal surface by a horizontal force $\vec{P}$. A smaller cube of mass 4.0 kg is in contact with the front surface of the large cube and will slide down unless $\vec{P}$ is sufficiently large. The coefficient of static friction between the cubes is 0.71. What is the smallest magnitude that $\vec{P}$ can have to keep the small cube from sliding down?



Physics, 9th Ed, Ch4 Q86

11 A solid cylinder (radius = 0.150 m, height = 0.120 m) has a mass of 7.00 kg. This cylinder is floating in water ($\rho_{water} = 1000$ kgm^{-3}). Then oil ($\rho_{oil} = 725$ kgm^{-3}) is poured on top of the water until it covers the cylinder completely (shown in picture). How much height of the cylinder is in the oil?



Physics, 9th Ed, Ch11 Q51