Name: ____ Class: __________ Date: ___________

Sec 3 Physics

Worksheet 9: Forces and Dynamics (Suggested Answers)

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.

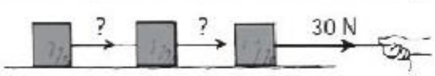
Yes. An object that is tossed upward in the air has a constant acceleration of g = 9.81 m s^{-2}. Its velocity keeps changing and eventually changes direction at the top of the trajectory.

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

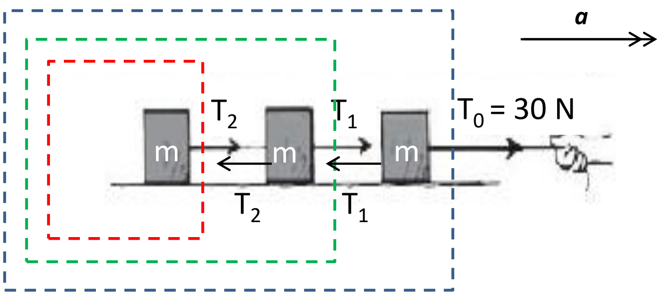
It is impossible to do so because Newton's 1st law implies that all objects without a resultant force must travel in a straight line at a constant speed.

Alternatively, you can think of an object moving in a curved path must have a constantly changing velocity because its direction component is changing. To change velocity requires acceleration. To have acceleration requires a force.

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?



This question is very easy to solve if you have chosen the right system(s) to analyse.



We can agree that all the blocks will have the same acceleration. Therefore, for the largest system, by Newton's 2nd law,

$T_0 = 3ma = 30$ N [For the system of three blocks, all forces cancel out except for T_0. Therefore, $\sum F = T_0$]

Similarly, $T_1 = 2ma = 20$ N [Inside the system (green dotted line), the mass = 2m while the only unbalanced force is T_1.]

and $T_2 = ma = 10$N

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

They are equal.

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!)

The book and the paper fall together at the same rate. The surface area of the paper cannot be larger than that of the book. The book shielded the paper from the effects of air resistance.

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

The terminal speed before opening the parachute is larger than after opening the parachute. When the parachute is first opened, the air resistance is greater than the weight, and so there is a resultant upward force, and the parachutist slows down. The magnitude of air resistance is dependent on the speed of the object. So as the parachutist slows down, the air resistance due to the parachute decreases until it is finally equal to the weight. At that point, there is a new but lower terminal speed.

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?

The cat has reached terminal velocity by the time it has fallen 20-storey.

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

When the upward forces equal to the downward forces acting on the sphere. Upward forces are drag force and upthrust. The downward force is the weight.

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?

The iron ball hits the ground first.

The explanation is the same for the man and woman parachutists in Example 15. The iron ball has a greater weight, thus requiring a greater drag force to counter it. The reasoning is as follow: The drag forces on both balls start to increase during the fall. As the drag forces increase, it will come a time when the drag force on the wooden ball balances the wooden ball’s weight first. At this time, the wooden ball reaches its terminal velocity. However, the drag force on the iron ball has yet to balance the iron ball's weight and will continue to accelerate until eventually, it too is balanced by a greater drag force. The terminal velocity of the iron ball will be greater.

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?

No. Two forces are acting on him; the weight and the air drag.

b Is a satellite above the atmosphere that circles the Earth in free fall?

Yes. The satellite above the atmosphere has only one force acting on it; its weight, and therefore, it is indeed free-falling towards the Earth. Free falling does not mean that the object must fall vertically downward toward Earth. If it helps, you should know that the Moon is also free-falling toward Earth, and obviously, it doesn't crash onto the Earth.

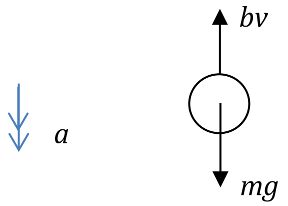
SECTION B: MULTIPLE CHOICE QUESTIONS

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 $\frac{bv}{m}$

$$\sum F_y = mg - bv = ma$$
$$\Rightarrow m(g-a) = bv$$
$$\Rightarrow g - a = \frac{bv}{m}$$
$$\Rightarrow a = g - \frac{bv}{m}$$

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

A 1.0 ms^{-2}

B 2.0 ms^{-2}

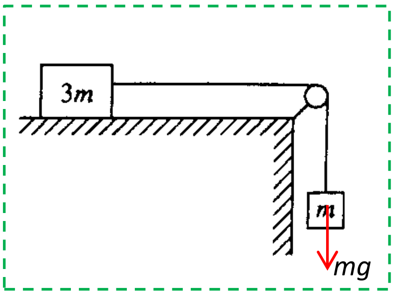
C 4.0 ms^{-2}

D 8.0 ms^{-2}

E 12.0 ms^{-2}

$$s = ut + \frac{1}{2}at^2$$
$$4 = 0 + \frac{1}{2}(a)(2.0)^2$$
$$a = 2.0 \text{ ms}^{-2}$$

4



System = *3m* + *m* blocks
mg is the only unbalanced force in this system.

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*?

Consider the combined system as one body:
$mg = (m + 3m)a$ since the system goes with a constant acceleration
$a = \frac{g}{4}$

Note: Many students will think that since the 3*m* block offers no friction, the *m* block would be in free fall (or acceleration = *g*). This is not correct. While the 3m block does not provide friction, it provides resistance to motion due to inertia. For the same force, the greater mass experiences a lower acceleration.

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 the Earth. The time it takes for the apple to fall to the ground compared with an apple dropped from the same height on the Earth is

A the same

B $\sqrt{6}$ times as long

C 6 times as long

D 36 times as long

since the distance dropped is the same:

$$s_{earth} = s_{moon}$$

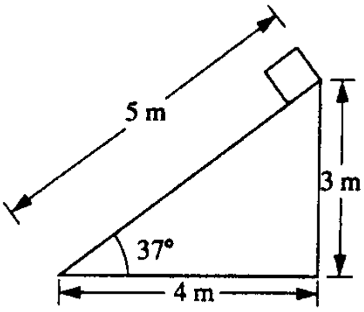
$$\frac{1}{2}g_{earth}t_{earth}^2 = \frac{1}{2}g_{moon}t_{moon}^2$$

$$\frac{1}{2}g_{earth}t_{earth}^2 = \frac{1}{2}\left(\frac{1}{6}g_{earth}\right)t_{moon}^2$$

$$t_{moon} = \sqrt{6}t_{earth}$$

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

6



A plane 5 metres in length is inclined at an angle of 37°, as shown above. A block of weight 20 newtons 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

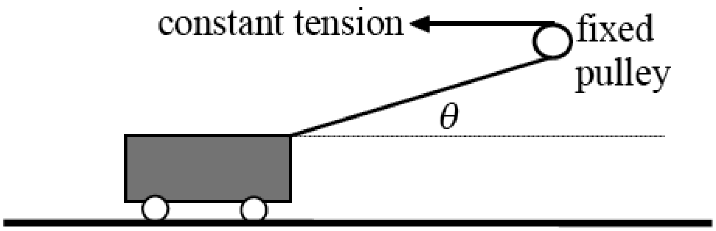
$$weight = mg$$
$$20 = m(9.81)$$
$$m \approx 2kg$$

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

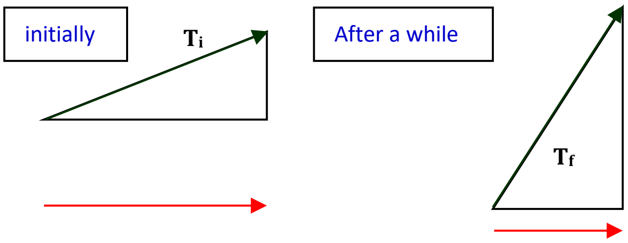
$$N = mg\cos 37$$
$$= 2(9.81)(\cos 37)$$
$$\approx 16N$$

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

The horizontal component of the tension of the string that is attached to the cart is responsible for the acceleration.

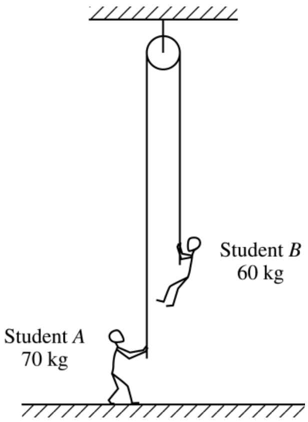


We can see that although *T* remains constant (same magnitude) but the horizontal component (red arrow) has decreased.

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

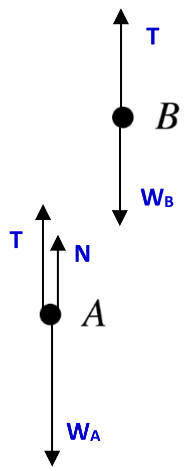
SECTION C: STRUCTURED QUESTIONS

1



A rope of negligible mass passes over a pulley of negligible mass attached to the ceiling, as shown above. One end of the rope is held by Student *A* of mass 70.0 kg, who is at rest on the floor. The opposite end of the rope is held by Student B, who has a mass 60.0 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 Calculate the magnitude of the force exerted by the floor on Student *A*.

By Newton's 2nd law,

$$N + T = m_A g$$
$$N = m_A g - T$$
$$= m_A g - m_B g$$
$$= (m_A - m_B) g$$
$$= (10)(9.81) = 98.1 \text{ N}$$

According to B's free body diagram, T = $m_B g$

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

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

Consider forces acting on student *B*,

$$T - mg = ma$$
$$T = m(g + a)$$
$$T = 60(9.81 + 0.25)$$
$$= 603.6\ \mathrm{N}$$

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

No. The tension acting on Student *A* is 603.6 N and is insufficient to lift him as his weight is $(70 \times 9.81) = 686.7\ \mathrm{N}$.

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

To lift Student A, the force of tension must be at least 686.7 N.

$$T = 60(a_{\min} + g)$$
$$a_{\min} = \frac{686.7}{60} - 9.81$$
$$= 1.64\ \mathrm{m\ s^{-2}}$$

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

a If 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.

By Newton's 2nd law,

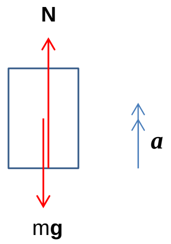
$$\sum F = ma$$

$$N - mg = ma$$

$$m = \frac{N}{g+a}$$

$$= \frac{720}{9.81 + 2.00}$$

$$= 61.0\text{ kg}$$



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

By Newton's 2nd law,

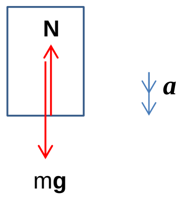
$$\sum F = ma$$

$$mg - N = ma$$

$$a = \frac{mg - N}{m}$$

$$= \frac{61.0(9.81) - 450}{61.0}$$

$$= 2.43\text{ m s}^{-2}$$



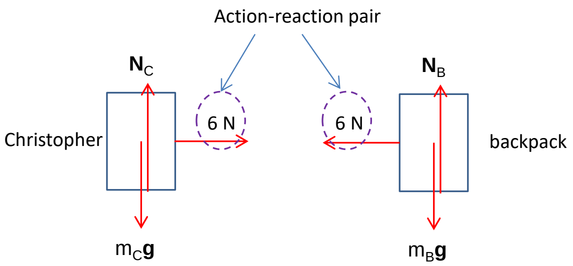
c The rope of the lift suddenly snaps. Before the safety devices kick in, what would the reading on the bathroom scale be? Explain your answer.

The scale reading would be zero.

Alicia and the scale are in free fall.

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 on Christopher. Indicate which pair(s) of forces acting on these 2 objects are action-reaction pairs.



b Calculate the acceleration of the backpack.

Consider horizontal forces acting on the backpack, by Newton's 2nd law,

$$\sum F_{horizontal} = m_B a_B$$

$$6 = m_B a_B$$
$$= 12 a_B$$
$$a_B = 0.5 \text{ m s}^{-2}$$

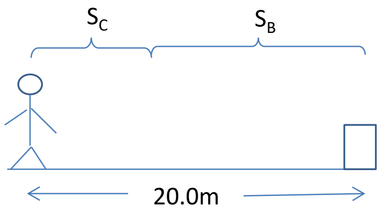
c Calculate the acceleration of Christopher.

Consider horizontal forces acting on Christopher, by Newton's 2nd law,

$$\sum F_{horizontal} = m_C a_C$$
$$6 = m_C a_C$$
$$= 80a$$
$$a_C = 0.075 \text{ ms}^{-2}$$

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

We need to find the displacement of Christopher s_{c}, as shown in the diagram.



$$s_c = \frac{1}{2}a_c t^2 \;\Rightarrow\; t^2 = \frac{2s_c}{a_c} \quad \cdots \quad (1)$$

$$s_B = \frac{1}{2}a_B t^2 \quad \cdots \quad (2)$$

t is the same for both objects.

$$s_c + s_B = 20.0$$

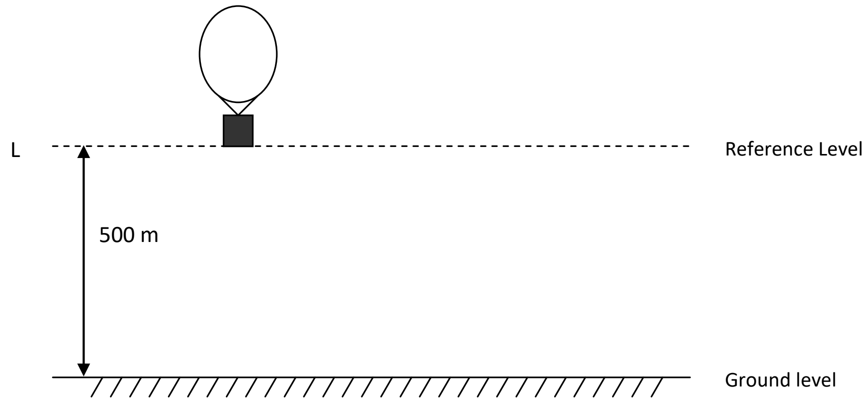
$$s_c + \frac{1}{2}a_B t^2 = 20.0$$

$$s_c + \frac{1}{2}a_B\left(\frac{2s_c}{a_c}\right) = 20.0$$

$$s_c\left(1+\frac{0.5}{0.075}\right) = 20.0$$

$$s_c = 2.61\text{ m}$$

4 With a 1.00×10^2 kg basket attached, a hot-air balloon was moving vertically downwards with a constant speed of 10.0 m s^{-1}, as shown in the diagram below. At time t = 0 s, the hot-air balloon reached level *L*, 5.00×10^2 m above the ground. The combined mass of the hot-air balloon with the basket was 3.00×10^3 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.

Resultant force = 0

Constant velocity $\Rightarrow$ resultant acceleration = 0 $\Rightarrow$ resultant force = 0 (by Newton's 2nd law)

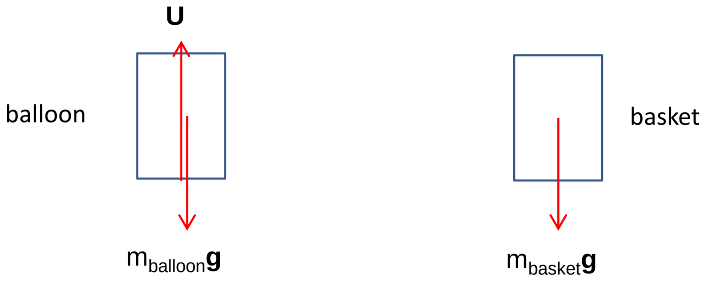
OR Newton's 1st law

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

$$\begin{aligned} \text{upward force} &= \text{weight of the hot air balloon} + \text{basket} \\ &= \left(3.00 \times 10^3 \text{ kg}\right)\left(9.81 \text{ N kg}^{-1}\right) \\ &= 2.94 \times 10^4 \text{ N} \end{aligned}$$

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.

$$s = ut + \frac{1}{2}at^2$$

$$\left(5.00\times10^2\ \text{m}\right) = \left(10.0\ \text{m s}^{-1}\right)t + \frac{1}{2}\left(9.81\ \text{m s}^{-2}\right)t^2$$

$$t = \frac{-10 \pm \sqrt{100 - 4(4.905)(-500)}}{2(4.905)}$$

$$= 9.13\ \text{s}$$

(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.

$$\text{constant upward force} = \text{original weight of } (\text{balloon} + \text{basket})$$
$$= 2.94\times10^4\ \text{N}$$

After the basket is released, the upward force acting on the balloon will be slightly greater than the weight of the balloon. The upward force remains unchanged because it is dependent on the volume of the hot-air balloon's canopy, which is not changed.

$$\text{resultant upward force on the balloon} = \text{weight of basket}$$
$$= \left(1.00\times10^2\ \text{kg}\right)\left(9.81\ \text{N kg}^{-1}\right)$$
$$= 981\ \text{N}$$

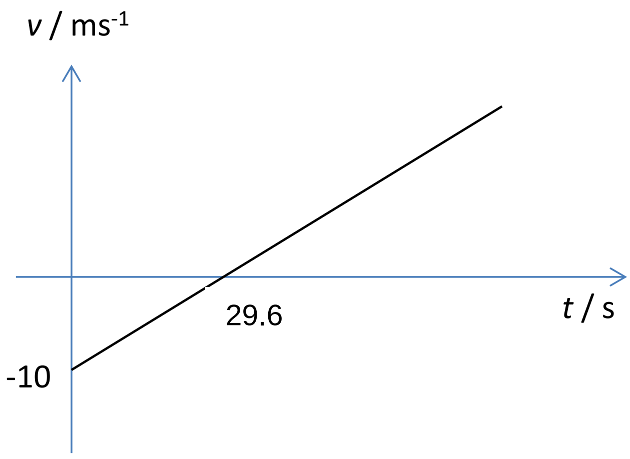
$$\text{resultant acceleration of the balloon} = \frac{\sum F}{m_{balloon}}$$
$$= \frac{981\ \text{N}}{2.90\times10^3\ \text{kg}}$$
$$= 0.338\ \text{m s}^{-2}$$

Time taken to come to a momentary stop, $t = \dfrac{v-u}{a}$

$$= \frac{0 - 10.0 \text{ m s}^{-1}}{-0.338 \text{ m s}^{-2}}$$

$$= 29.6 \text{ s}$$

(Taking downward as positive in the above working.)



The initial velocity of the balloon is 10 m s^{-1} downwards. Thus, the balloon first slows down until it comes to a momentary stop at $t = 29.6$ s , and then it starts to rise with constant acceleration.

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.

No effect.

The horizontal wind does not affect the vertical motions of the basket and balloon. It will only add a horizontal displacement to the two objects.

(Note: horizontal and vertical components of motion are <u>independent</u> of each other.)

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 What is the magnitude of the least acceleration the monkey must have if it lifts the package off the ground?

Applying Newton's 2nd law to

the monkey: $T - m_m g = m_m a$

the package: $T - m_p g = 0 \Rightarrow T = m_p g$

the acceleration of the package is zero because it is just about to be lifted from ground.

$$\therefore a = \frac{T - m_m g}{m_m} = \frac{m_p g - m_m g}{m_m} = \frac{(20.0 - 15.0)\ \text{kg} \times (9.81\ \text{m s}^{-2})}{15.0\ \text{kg}} = 3.27\ \text{m s}^{-2}$$

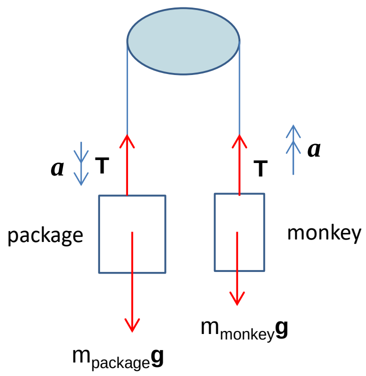
b After the package has been lifted, the monkey stops its climb and holds on to the rope. What are

(i) the tension in the rope and

Applying Newton's 2nd law to

the monkey: $T - m_m g = m_m a$

the package: $m_p g - T = m_p a$



$$T - m_m g = m_m \left(\frac{m_p g - T}{m_p} \right)$$

$$\therefore T = (15.0)(9.81) + 15.0 \left(\frac{(20.0)(9.81) - T}{20.0} \right)$$

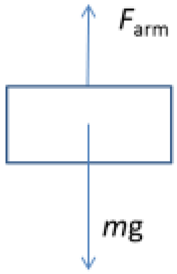
$$T = 168\ \text{N}$$

(ii) the monkey's acceleration?

$$a = \frac{T - m_m g}{m_m} = \frac{168 - (15.0)(9.81)}{15.0} = 1.40\ \text{m s}^{-2}$$

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 m s^{-2}.



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

By Newton's 3rd law, the downward pull of the briefcase is equal to F_{arm}.

By Newton's 2nd law,

$$mg - F_{arm} = ma$$
$$2.5(9.81) - F_{arm} = 2.5(1.50)$$
$$F_{arm} = 21\text{ N}$$

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?

$$v^2 = 2as \qquad (u = 0)$$

$$a = \frac{(965)^2}{2(0.450)}$$

$$= 1.03 \times 10^6 \text{ m s}^{-1}$$

By N2L, $F = ma$

$$= (4.20 \times 10^{-3})(1.03 \times 10^6)$$

$$= 4.35 \times 10^3 \text{ N}$$

OR

Work done by rifle $= \Delta KE_{bullet}$

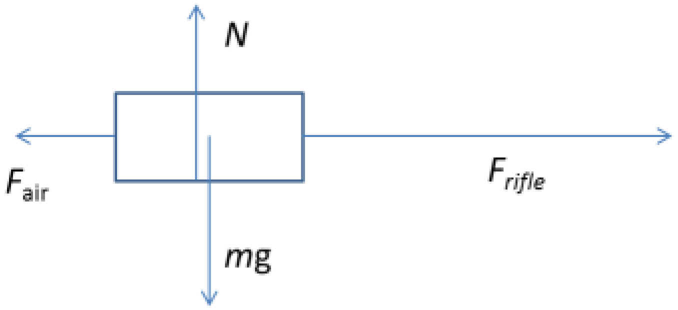
$$F \cdot s = \frac{1}{2} m v^2$$

$$F = \frac{1}{2} \cdot \frac{(4.20 \times 10^{-3} \text{ kg})(965 \text{ m s}^{-1})^2}{0.450 \text{ m}}$$

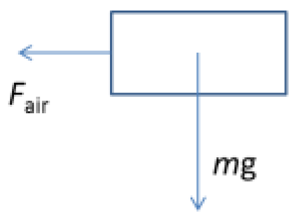
$$= 4.35 \times 10^3 \text{ N}$$

b Draw a free-body diagram of the bullet

(i) while it is in the barrel (*assuming the presence of air drag*)



(ii) just after it has left the barrel



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

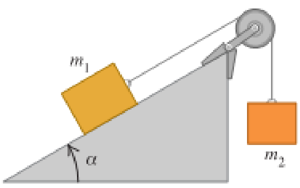
$$\text{number of } g's = \frac{1.03\times10^{6}}{9.81}$$
$$= 1.05\times10^{5}\ g$$

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

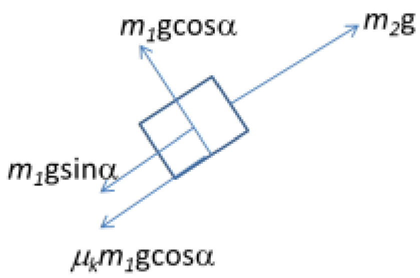
$$t = \frac{v}{a} = \frac{965}{1.03\times10^{6}} = 9.33\times10^{-4}\ \text{s}$$

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.



If m_1 moves up with constant speed, then

$$W_1 \sin\alpha + f = W_2 \qquad (f = \mu_k N)$$

$$m_1 g \sin\alpha + \mu_k m_1 g \cos\alpha = m_2 g$$

$$m_2 = m_1(\sin\alpha + \mu_k \cos\alpha)$$

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.

If m_1 moves down with constant speed, then

$$W_1 \sin\alpha - f = W_2 \qquad (f = \mu_k N)$$

$$m_1 g \sin\alpha - \mu_k m_1 g \cos\alpha = m_2 g$$

$$m_2 = m_1(\sin\alpha - \mu_k \cos\alpha)$$

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

From the answers in (a) and (b), we can conclude

$$m_1(\sin\alpha - \mu_s \cos\alpha) \le m_2 \le m_1(\sin\alpha + \mu_s \cos\alpha)$$

remember to change μ_k to μ_s

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 Ns/m^2 if we could neglect buoyancy. Assume that the density of steel is 7.8 g cm^{-3}.

By Newton's 2nd law,

$$\frac{4}{3}\pi r^3 \rho g = 6\pi r \eta v$$

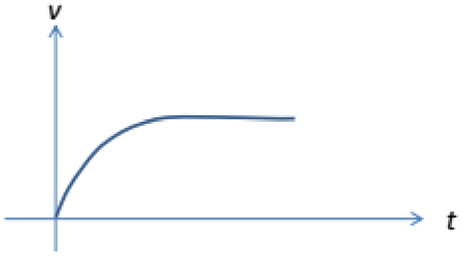
$$v = \frac{2r^2 \rho g}{9\eta}$$

$$= \frac{2\left(1.00\times10^{-3}\right)^2\left(7.8\times10^3\right)(9.81)}{9(0.150)}$$

$$= 0.11\text{ m s}^{-1}$$

Is it possible to calculate how much time it takes for the steel ball to reach terminal velocity?

It would help if you recalled that the velocity-time graph looks like this:



We cannot use the simple kinematics equations to solve because the acceleration is not constant.

Applying Newton's 2nd law, we have

$$mg - 6\pi r \eta v = ma$$

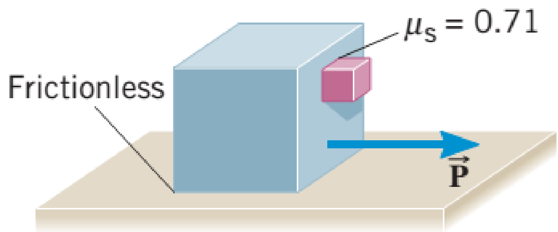
But a is not a constant, so we need to write it as $\frac{dv}{dt}$. So we have

$$mg - 6\pi r \eta v = m\frac{dv}{dt}$$

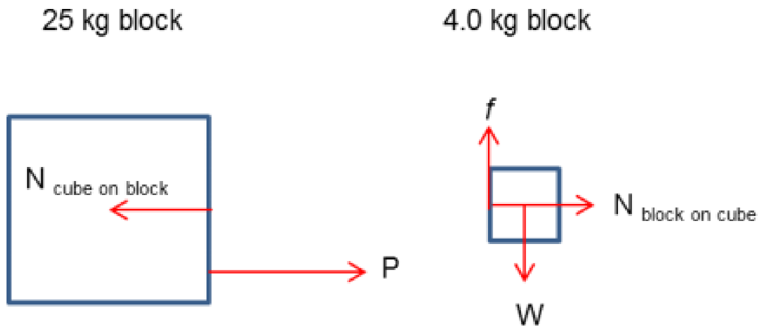
This equation is a first-order differential equation, and the technique to solve this equation is called *variables separable*. You may want to find out more about this technique on your own.

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 in order to keep the small cube from sliding down?



Consider the following free body diagrams,



To prevent sliding, the friction f must be equal to the weight of the small cube W.

$$f = m_{cube} g$$
$$\mu_s N = m_{cube} g$$
$$N = \frac{(4.0)(9.81)}{0.71} = 55.268 \text{ N}$$

To create a contact force of $N = 55.268$ N, the small cube must be accelerating to the right by

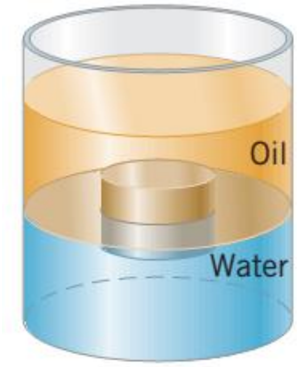
$$N = m_{cube} a$$
$$55.268 = 4.0a$$
$$a = 13.817 \text{ m s}^{-2}$$

Finally, force P is accelerating a total mass of 29 kg at $a = 13.817$ m s^{-2}. Hence,

$$P = m_{total} a$$
$$= 29(13.817)$$
$$= 4.00 \times 10^2 \text{ N}$$

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?



While in static equilibrium, the buoyant force must balance the weight,

$$F_{B_{water}} + F_{B_{oil}} = mg$$
$$\rho_{water} V_{water} g + \rho_{oil} V_{oil} g = mg$$
$$\rho_{water} V_{water} + \rho_{oil} V_{oil} = m$$

Let the height of the cylinder which is submerged in oil be x, then

$$\rho_{water} \pi r^2 (0.120 - x) + \rho_{oil} \pi r^2 x = 7.00$$
$$\pi (0.150)^2 \left[1000(0.120 - x) + 725x\right] = 7.00$$
$$\pi (0.150)^2 \left[120 - 1000x + 725x\right] = 7.00$$
$$-275x = \frac{7.00}{\pi (0.150)^2} - 120$$
$$x = 0.0762 \text{ m}$$

Physics, 9th Ed, Ch11 Q51