Set 6 Simple Force Problems - Newton's First and Second Laws

1. State Newton's First law. Describe two situations that would demonstrate this law.

2. State Newton's Second Law. Describe one situation that would demonstrate this law.

3. A 0.025 kg bullet is shot out of a 0.45 m rifle barrel. The force on the bullet is 3600 N. What is the muzzle speed (the speed that the bullet leaves the gun barrel) of the bullet?

4. A 12.0 g bullet travelling at 230 ms^{-1} enters a block of clay. The bullet is stopped in a distance of 0.32 m. What force was applied to the bullet by the clay?

5. A 36 000 kg cement truck accelerates from rest to a speed of 28 ms^{-1} in a time of 18.7 s.
a. What is the acceleration of the truck?

b. What is the net force that causes this acceleration?

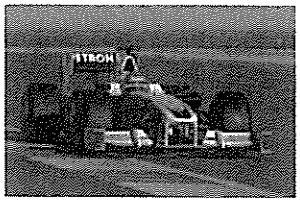
6. An F-l race has a mass of only 850 kg. It is able to generate a force of 8500 N against a frictional force of 1100 N.
a. What is the acceleration of this F-l car?

b. How far starting from rest will this car travel in 3.2 s?

c. What would the speed of this car be at 3.2 s?

Repeat #6 a - c for an ordinary car of mass 2300 kg and able to generate only 5500 N of force against the 1100 N of frictional Force.

(6)



Simple Force Problems – Newton's First and Second Laws

1. State Newton's First law. Describe **2 situations** that would demonstrate this law.

An object at rest will stay at rest and an object in motion will stay in motion unless acted upon by an external force.

- box flying forwards off back seat of car when car brakes.
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2. State Newton's Second Law. Describe **1 situation** that would demonstrate this law.

The acceleration of an object is directly proportional to the force acting on the object and indirectly proportional to an object's mass.

- loaded car accelerates slower than unloaded car
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3. A 0.025 kg bullet is shot out of a 0.45 m rifle barrel. The force on the bullet is 3600 N. What is the muzzle speed (the speed that the bullet leaves the gun barrel) of the bullet?

$F = 3600\ N$

$m = 0.025\ kg$

$a = ?$

$u = 0\ ms^{-1}$

$s = 0.45m$

$v = ?$

$F = ma$

$3600 = 0.025 \times a$

$a = \frac{3600}{0.025}$

$= 144000\ ms^{-2}$

$v^2 = u^2 + 2as$

$= 0^2 + 2 \cdot 144000 \cdot 0.45$

$= 129600$

$v = \sqrt{129600} = 360\ ms^{-1}$

The clay exerts a force of 0.99 N on the bullet.

4. A 0.012 g bullet travelling at 230 m/s enters a block of clay. The bullet is stopped in a distance of 0.32 m. What force was applied to the bullet by the clay?

$m = 0.012\,g = 1.2 \times 10^{-5}\,kg$ $\quad a = ?$ $\quad F = ?$

$u = 230\,ms^{-1}$

$v = 0\,ms^{-1}$

$s = 0.32\,m$

$v^2 = u^2 + 2as$

$0^2 = 230^2 + 2 \cdot a \cdot 0.32$

$\frac{-52900}{0.64} = a$

$a = -82656\,ms^{-2}$

$F = ma = 1.2 \times 10^{-5} \times -82656 = -0.99\,N$

5. A 36000 kg cement truck accelerates from rest to a speed of 28 m/s in a time of 18.7 s.

a. What is the acceleration of the truck?

$m = 36000\,kg$

$u = 0\,ms^{-1}$

$v = 28\,ms^{-1}$

$t = 18.7\,s$

$a = \frac{v - u}{t}$

$= \frac{28 - 0}{18.7} = 1.50\,ms^{-2}$

b. What is the net force that causes this acceleration?

$F = ma$

$= 36000 \times 1.50$ (use actual value!)

$= 5.39 \times 10^4\,N$

6. An F-1 race has a mass of only 850 kg. It is able to generate a total force of 8500 N against a frictional force of 1100 N.

a. What is the acceleration of this F-1 car?

$m = 850\,kg$

$\Sigma F = 8500 - 1100 = 7400\,N$

$a = ?$

$F = ma$

$7400 = 850 \times a$

$a = \frac{7400}{850}$

$= 8.71\,ms^{-2}$

b. How far starting from rest will this car travel in 3.2 s?

$u = 0$

$t = 3.2\,s$

$a = 8.71\,ms^{-2}$

$s = ?$

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

$= 0 \cdot 3.2 + \frac{1}{2} \cdot 8.71 \cdot 3.2^2$

$= 44.6\,m$

c. What would the speed of this car be at 3.2 s?

$v = ?$

$v = u + at$

$= 0 + 8.71 \cdot 3.2$

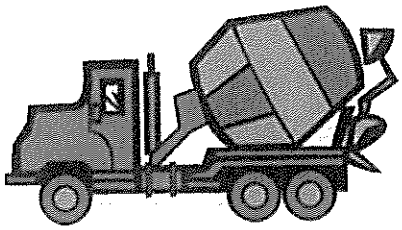
$= 27.9\,ms^{-1}$

7. Repeat #6 a – c for an ordinary car of mass 2300 kg and able to generate only 5500 N of force against the 1100 N of frictional Force.

$m = 2300\ kg$

$\Sigma F = 5500 - 1100$

$= 4400\ N$



a) $F = ma$

$4400 = 2300 \times a$

$a = 1.91\ ms^{-2}$

b) $u = 0$

$t = 3.2$

$a = 1.91$

$s = ?$

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

$= 0.3.2 + \frac{1}{2}\,1.91 . 3.2^2$

$= 9.79\ m$

c) $V = u + at$

$= 0 + 1.91 . 3.2$

$= 6.12\ ms^{-1}$

Motion Problems

Please show your work (PSYW) for the following problems.

1. An aeroplane accelerates down a run-way at 3.20 ms^{-2} for 32.8 s until it finally lifts off the ground. Determine the distance travelled before take-off.

$S = ut + \frac{1}{2} at^2$
$= 0 + \frac{1}{2} (3.2) (32.8)^2$
$= 1721.3m$

2. A race car accelerates uniformly from 18.5 ms^{-1} to 46.1 ms^{-1} in 2.47 seconds. Determine the acceleration of the car and the distance travelled.

$a = (v - u) / t$
$= (46.4 - 18.5) / 2.47$
$= 11.17\ m.s^{-2}$

$S = ut + \frac{1}{2} at^2$
$= 18.5(2.47) + \frac{1}{2} (11.17) (2.47)^2$
$= 79.8m$

3. A feather is dropped on the moon from a height of 1.40 meters. The acceleration of gravity on the moon is 1.67 ms^{-2}. Determine the time for the feather to fall to the surface of the moon.

$$t = \sqrt{\frac{2s}{a}} = \sqrt{\frac{2.8}{1.67}} = 1.29 \text{ seconds.}$$

4. A bullet leaves a rifle with a muzzle velocity of 521 ms^{-1}. While accelerating through the barrel of the rifle, the bullet moves a distance of 0.840 m. Determine the acceleration of the bullet (assume a uniform acceleration).

$v^2 = u^2 + 2as$
$521^2 = 0^2 + 2a(0.84)$
$521^2 = 1.68a$
$a = 521^2 / 1.68$
$= 161572 m/s^2$

5. An engineer is designing a runway for an airport. Several planes will use the runway and the engineer must design it so that it is long enough for the largest planes to become airborne before the runway ends. If the largest plane accelerates at 3.30 ms^{-2} and has a take-off speed of 88.0 ms^{-1}, what is the minimum length for the runway?

$$a = \frac{v - u}{t} \Rightarrow 3.3 = \frac{88 - 0}{t} \Rightarrow t = \frac{88}{3.3} = 26.67s$$

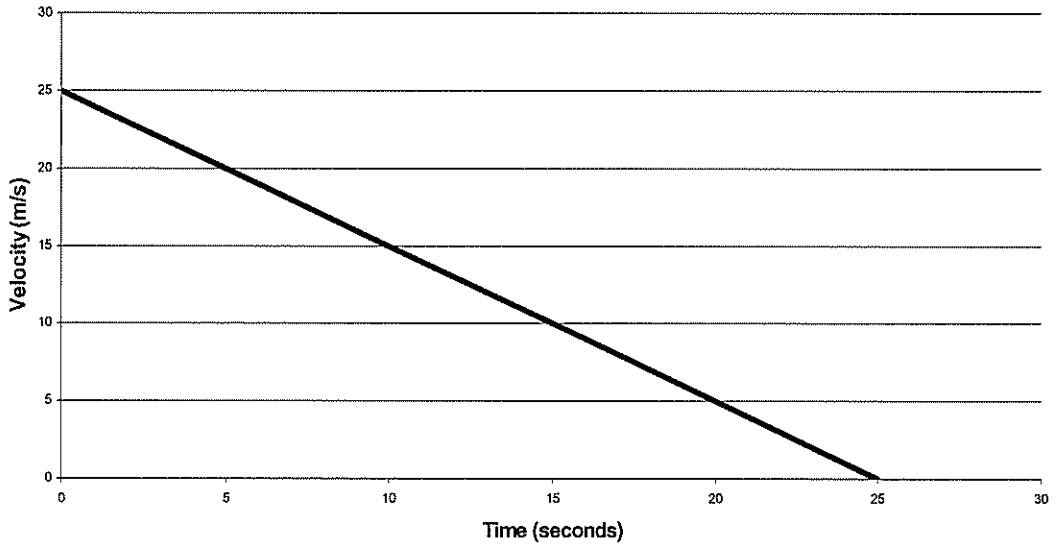
$S = ut + \frac{1}{2} at^2 = 0 + \frac{1}{2} (3.3) (26.67)^2 = 1173.6m$

6. A student drives 4.8-km trip to school and averages a speed of 22.6 ms^{-1}. On the return trip home, the student travels with an average speed of 16.8 ms^{-1} over the same distance. What is the average speed of the student for the two-way trip? (Be careful.)

$t_1 = s / v_1 = 4800 / 22.6 = 212.4s$
$t_2 = s / v_2 = 4800 / 16.8 = 285.7s$
$t_T = 212.4 + 285.7 = 498.1s$

$V_{av} = (2 \times 4800) / 498.1 = 19.3 m.s^{-1}$

7. Rennata Gas is driving through town at 25.0 ms^{-1} and begins to accelerate at a constant rate of -1.0 ms^{-2} Eventually Rennata comes to a complete stop. Represent Rennata's accelerated motion by sketching a velocity-time graph. Calculate the distance which Rennata travels while decelerating. Then use the velocity-time graph to determine this distance.



Kinematic equation solution:

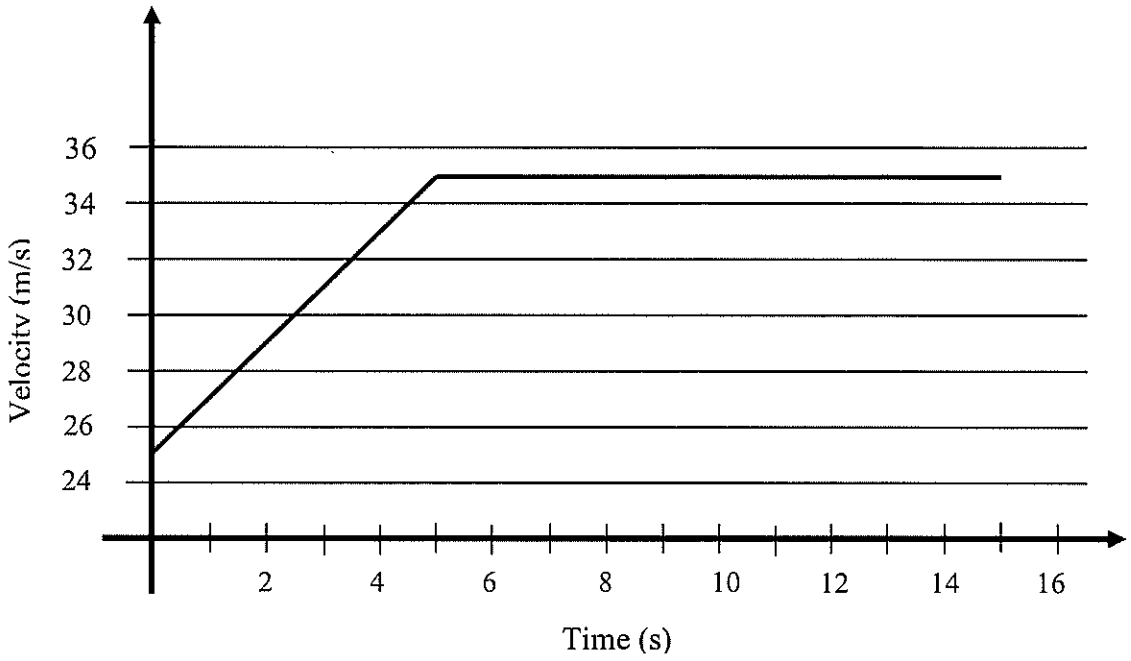
$a = (v - u) / t$
$-1 = (0 - 25) / t$
$-t = -25 \Rightarrow t = 25s.$

$S = ut + \frac{1}{2} at^2$
$= (25 \times 25) + \frac{1}{2} (-1) (25)^2$
$= 625 - 312.5$
$= 312.5m$

Graphical solution:

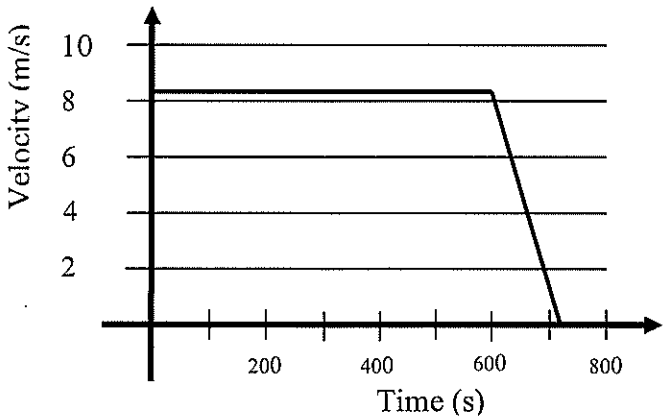
Distance $= \frac{1}{2} b \times h$
$= \frac{1}{2} 25 \times 25$
$= 312.5m$

8. Otto Emissions is driving his car at 25.0 ms^{-1}. Otto accelerates at 2.0 ms^{-2} for 5 seconds. Otto then maintains a constant velocity for 10 more seconds. Determine the distance Otto travelled during the entire 15 seconds. (Consider using a velocity-time graph.)



S = ½(b × h) + (l × w)
= ½ (10 × 5) + (10 × 10)
= 25 + 100
= 125m.

9. Holden Together travels at a constant velocity covering 0.5 km each minute for 10 minutes. Holden then decelerates at 0.07 ms^{-2} for 2 minutes. Determine the total distance travelled by Holden Together during the 12 minutes of motion. (Consider using a velocity-time graph.)



(Convert units; ½ km per minute = 500m per 60 seconds = 8.33m/s.)

Total distance travelled using graphical method:

S = (l × w) + ½ (b × h)
= (8.33 × 600) + ½ (8.33 × 120)
= 4998 + 499.8
= 5497.8m

Worksheet: Weight

Weight is a measure of the _____ force between the object and the earth. The acceleration of gravity on Earth is _____. Weight is measured in units of _____. If one object has more mass than another then it weighs (more / less) than the other object.

As an astronaut goes to the moon, his mass _____ but his

weight _____. This is because as he got further away from the Earth, the acceleration of gravity _____.

Weight Problems

1. Find the missing value for each set of data below

Force (F) = ?	Force (F) = 490N
Mass (m) = 75 kg	Mass (m) = ?
Gravity (g) = 9.8 m/s/s	Gravity (g) = 9.8 m/s/s

2. What is the force on a 1 kg ball that is falling freely due to the pull of gravity?

3. What is the mass of a person who weighs 500 N?

4. What is the weight of an object (on earth) that has a mass of 45 kg?

5. The value of gravitational pull on the moon is 1.6 m/s/s. What is the weight of a 75 kg astronaut on the moon?

6. A space ship has a mass of 9000 kg. The space ship is launched from Earth and lands on a distant planet where it has a weight of 390000 N. What is the acceleration of gravity on this planet?

7. Big Bertha tips the scales at 950 Newtons. What is her mass?

8. If my mass is 100 kilograms, what is my weight?

9. The elevator in the new office building warns that it can safely lift 300 kg at one time. If John (850 N), Betty (530 N), Robert (740 N) and Alice (610 N) all get in the elevator at once, can the elevator safely carry them up to the third floor? Explain why or why not.

Worksheet: Weight

Weight is a measure of the gravitational force between the object and the earth. The acceleration of gravity on Earth is $9.8\ ms^{-2}$. Weight is measured in units of Newtons. If one object has more mass than another then it weighs (more / less) than the other object.

As an astronaut goes to the moon, his mass stays the same but his weight decreases. This is because as he got further away from the Earth, the acceleration of gravity decreases.

Weight Problems

1. Find the missing value for each set of data below

Force (F) = ? 735 N (75×9.8)
Mass (m) = 75 kg
Gravity (g) = 9.8 m/s/s

Force (F) = 490N
Mass (m) = ? 50 kg $\left(\frac{490}{9.8}\right)$
Gravity (g) = 9.8 m/s/s

2. What is the force on a 1 kg ball that is falling freely due to the pull of gravity?
$F = ma = 1 \times 9.8 = 9.8\ N$

3. What is the mass of a person who weighs 500 N?
$F = ma \therefore m = \frac{F}{a} = \frac{500}{9.8} = 51\ kg$

4. What is the weight of an object (on earth) that has a mass of 45 kg?
$F = ma = 45 \times 9.8 = 441\ N$

5. The value of gravitational pull on the moon is 1.6 m/s/s. What is the weight of a 75 kg astronaut on the moon? $F = ma = 75 \times 1.6 = 120\ N$

6. A space ship has a mass of 9000 kg. The space ship is launched from Earth and lands on a distant planet where it has a weight of 390000 N. What is the acceleration of gravity on this planet? $a = \frac{F}{m} = \frac{390000}{9000} = 43.3\ ms^{-2}$

7. Big Bertha tips the scales at 950 Newtons. What is her mass? $m = \frac{F}{a} = \frac{950}{9.8} = 96.9\ kg$

8. If my mass is 100 kilograms, what is my weight?
$F = ma = 100 \times 9.8 = 980\ N$

9. The elevator in the new office building warns that it can safely lift 300 kg at one time. If John (850 N), Betty (530 N), Robert (740 N) and Alice (610 N) all get in the elevator at once, can the elevator safely carry them up to the third floor? Explain why or why not.

$\Sigma F = 850 + 530 + 740 + 610$
$= 2730\ N$
$a = 9.8\ ms^{-2}$

$m = \frac{F}{a} = \frac{2730}{9.8} = 279\ kg$

Yes it can! Mass of people less than 300kg.

Gravity and Motion Worksheet

Try This!

a. Position a flat ruler ready to knock one of the coins off the desk like you are playing pool or billiards. Place another coin on top of the ruler, near the end that is hitting the first coin.
b. Hold the ruler by the end that is on the desk. Move the ruler quickly so that the ruler knocks the coin off the table and so that the other coin also drops off the ruler. Repeat several times.
c. What order do the pennies hit the ground?

1. What is the acceleration of gravity?

2. Knowing this, calculate the velocity of the following objects that have been in free fall.
   $v = u + at$ *is the same as* $v = gt$ *if* u *is zero and* $a = g$

	g = Gravity (m/s/s)	**t** = time (s)	**v** = Velocity (m/s)
a.	9.8	2	
b.		10	
c.		14	
d.		20	
e.		1	

3. If a skydiver is falling from an airplane for 2 seconds, how fast is she going?

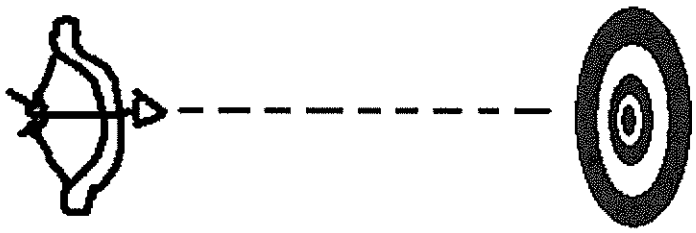
4. Air resistance is affected by the _____ and _____ of an object.

5. Air resistance matches the _____ when the net force equals zero.

6. When falling object stops _____, it has reaches _____ velocity.

7. Free fall occurs because of high air resistance (true or false)

8. If you aimed this arrow directly at the bull's-eye, would it hit the target? Why or why not?



9. A bullet takes longer to hit the ground then an object that is dropped. (true or false)

10. Why is your weight less on the Moon than on Earth, but your mass is the same?

11. An anvil of mass 20 kg and apple of mass 0.200 kg are both dropped from 200m above the floor.

    a. What is the acceleration due to gravity on the anvil?

    b. What is the acceleration due to gravity on the apple?

    c. What is the initial velocity of the anvil?

    d. What is the velocity of the anvil after 5 seconds?

    e. What is the velocity of the anvil after 20 seconds?

    f. What is the distance traveled after 5 seconds?

    g. What is the distance traveled after 20 seconds?

12. A ball is dropped from a building from rest that is 250m tall. A timed camera takes a photo every second for 6 seconds. Draw a scaled diagram showing the location of the ball in each photo (only draw the building once and just label the ball's position).

13. A ball is dropped from a building from rest, how tall is the building, if it takes the ball 2.5s to reach the ground?

14. You fall off your bunk bed that is 2.7m above the ground. How long does it take before you hit your head on the floor?

15. A ball is throw up in the air with initial velocity of 2.5 m/s ,
    a. how long does it take the ball to reach maximum height?
    b. How long will the ball take to return to its original position from the maximum height?
    c. What is the velocity of the ball when it returns to its starting position?

16. Upton Chuck is riding the Giant Drop at Great America. If Upton free falls for 2.6 seconds, what will be his final velocity and how far will he fall?

17. Find the details of the Freefall ride at Adventure World from the Adventure World website.

    a. How long will the ride take to reach its maximum fall speed if it is accelerated by gravity?
    b. How long will the entire falling portion of the ride take (ignore slowing down at the end)?
    c. Why is calling the ride "Freefall" not acceptable from a Physics perspective?