Science 10 Honours    Newton's Laws

## Newton's First Law of Motion

If no net force acts on an object, it maintains its state of rest or its constant speed in a straight line.

1. A jet plane is traveling at a constant speed in a straight line in level flight. What does this tell you about the forces acting on it?

2. A woman pushes a refrigerator across the floor at a steady speed of 20 cm/s. If she has to push with a force of 400 N to keep it moving, is the force of friction on the refrigerator more than 400 N, less than 400 N, or equal to 400 N?

3. A 1200 kg boat accelerates steadily at 0.05 $m/s^2$ in a straight line. Are the forces on this boat balanced or unbalanced? Explain.

*When forces acting on a stationary object are balanced, it will remain at rest. If the forces acting on a moving object are balanced, it will continue to move at a constant speed in a straight line.*

*If the forces acting on an object are not balanced, it will accelerate in the direction of the net force.*

## Newton's Second Law of Motion

If an unbalanced force acts on an object, the object accelerates in the direction of the force.
The acceleration varies directly with the unbalanced force.
The acceleration varies inversely with the mass of the object.

What is the acceleration of a 70 kg skater, acted upon by an unbalanced force of 161 N?

What is the acceleration of a 1000 kg car, if its engine pushes with a force of 500 N against a 100 N force of friction?

4. The net force on a 5.0 kg bowling ball is 20 N. What is its acceleration?

5. A baseball hit by a bat with a force of 1000 N accelerates at $4.0 \times 10^3$ m/s$^2$. What is the ball's mass?

6. What unbalanced force is needed to accelerate a $3.0 \times 10^4$ kg spacecraft at 2.5 m/s$^2$?

7. How much force is needed to accelerate a 2.0 kg block of wood at 4.0 m/s$^2$ along a rough table, against a 10 N force of friction?

**Newton's Third Law of Motion**

For every action force, there is an equal and opposite reaction force.

8. What is the reaction force to the action force in each of the following situations?
   a. A football player kicks the football with a force of 500 N[N].
   b. A book pushes down on a desk with a force of 25 N.
   c. A crane lifts a steel girder with a force of 6000 N[up].

9. When you drop a tennis ball, it bounces back up off the ground. Explain in detail the force that causes this.

10. Explain how a person trapped, motionless, in the center of a frictionless ice rink can get to the side of the rink and escape.

11. A man wants to test a rope. He ties one end to a telephone pole and the other to a horse and makes the horse pull as hard as it can. It is not quite strong enough to break the rope. The man brings in a second horse of identical strength to take the place of the telephone pole. Will the rope break when the two horses pull in opposite directions as hard as they can? Explain your answer.

More Practice for You: Please answer the following on a separate piece of paper.

1. What is the reaction force in each of the following cases?
   a. A canoe paddle pushes on water with a force of 150 N[E].
   b. A bulldozer pushes a large rock with a force of $10^4$ N[W] at 0.2 m/s.
   c. A baseball hits a window with a maximum force of 400 N[S] and breaks it.
   d. The wheels of a car push on a road with a force of 250 N[S] and 2500 N[down].

2. Use Newton's first law of motion to explain what will happen in each of the following:
   a. A car attempts to stop at a traffic light on an icy street.
   b. A truck attempts to turn a corner on an icy expressway.
   c. A passenger in a car does not have the seat belt buckled when the car runs into a snowdrift.
   d. An airline passenger attempts to sip a cup of coffee when the airplane suddenly drops one meter.

3. Harry is pushing a car down a level road at 2.0 m/s with a force of 243 N. The total force acting on the car in the opposite direction, including road friction and air resistance, is one of the following. Which one? Why?
   a. slightly more than 243 N   b. exactly equal to 243 N   c. slightly less than 243 N

4. What force would be required in each case to accelerate a 0.50 kg grapefruit at:
   a. 4.0 $m/s^2$   b. 8.0 $m/s^2$   c. 12 $m/s^2$

5. What acceleration would an unbalanced force of 84 N produce on each of the following masses?
   a. 4.2 kg   b. 8.4 kg   c. 12.6 kg

6. A 1200 kg car traveling at 50 km/h experiences an air resistance of 5000 N and road friction of 2200 N. If the wheels push with a force of 7500 N, what is the car's acceleration?

7. An 1100 kg car accelerates at 3.40 $m/s^2$. If the wheels exert a force of 5600 N on the road, calculate the force resisting the motion.

8. Two boys, one with a mass of 60 kg and the other with a mass of 90 kg are standing side by side in the middle of an ice rink. One of them pushes the other with a force of 360 N for 0.10s. Assuming that the ice surface is frictionless:
   a. What is the acceleration of each boy?
   b. What speed will each reach after the 0.10 s?
   c. Does it matter which boy did the pushing?

9. A block of wood of mass 6.0 kg sliding along a skating rink at 12.5 m/s[W] slides onto a rough part of the ice, which exerts a 30 N force of friction on the block of wood. Calculate:
   a. the acceleration of the block of wood
   b. the time it takes the block of wood to stop

10. A fully loaded Saturn V rocket has a mass of $2.92 \times 10^6$ kg. Its engines have a thrust of $3.34 \times 10^7$ N.
    a. What is the downward force of gravity on the rocket at balst-off?
    b. What is the unbalanced force on the rocket at blast-off?
    c. What is the acceleration of the rocket as it leaves the launching platform?
    d. As the rocket travels upwards, the engines thrust remains constant, but the mass of the rocket decreases. Why?
    e. Does the acceleration of the rocket increase, decrease, or remain the same as the engines continue to fire?

11. Calculate the initial acceleration of a 13140 kg V-2 rocket bomb fired vertically if the thrust of its engines is $2.63 \times 10^5$ N. Then calculate the rocket's acceleration near "burn-out" when its mass is only 4170 kg.

12. A 5.0 kg stone is sinking in water at a constant speed of 5.0 m/s. What is the upward force of the water on the stone?

13. The hero in a cartoon has a sailboat but no wind. To make a quick escape, the ingenious character attaches an electric fan to the back of the boat to blow air into the sails. Why would this not work, even if there was an extension cord long enough?

14. What change in velocity would be produced by an unbalanced force of $2.0 \times 10^4$ N acting for 6.0 s on a 2000 kg dragster?

15. Calculate the unbalanced force acting on a 4000 kg truck that changes speed from 22.0 m/s[N] to 8.0 m/s[N] in 3.50 s.

16. How long does it take a 50 kg rider on a 10 kg bicycle to accelerate from rest to 4.0 m/s[E] if the unbalanced force acting on the bicycle is 48 N[E]?

17. What is the unbalanced force accelerating a 5.0 kg cannonball from rest to 150 m/s[W], if the force acts for 0.050 s?

18. What is the final velocity of a 150 kg motorcycle driven by a 50 kg rider, accelerated from rest for 11.0 s by an unbalanced force of 800 N[S]?

19. A 0.50 kg model rocket accelerates from 20 m/s[up] to 45 m/s[up] in 0.70 s. Calculate the unbalanced force acting on it.

20. A 2.0 kg sponge is dropped from rest, pulled down by gravity. How fast will it be traveling in 6.0 s, if a 5.0 N force of air resistance acts on it?

1a. water pushes on paddle with a force of 150 N[W]. b. rock pushes on bulldozer with a force of $10^4$ N[E] at 0.2 m/s. c. window hits baseball with a force of 400 N[N]. d. road pushes on wheels with a force of 250 N[N] and 2500 N[up]. 2a. car moves in a straight line at constant speed through the light b. truck goes in a straight line at constant speed into the ditch c. snowdrift stops the car but passenger continues to move at a constant speed into the windshield d. if person is strapped in, they drop, their cup drops, but coffee hangs momentarily in the air, ending up on their lap 3. b. exactly equal to 243 N 4. a. *2.0 N* b. *4.0 N* c. *6.0 N* 5a. *20 m/s²* b. *10 m/s²* c. *6.7 m/s²* 6. *0.250 m/s²* 7. *$1.86 \times 10^3$ N* 8. a. *6.0 m/s², 4.0 m/s²* b. *0.6 m/s, 0.4 m/s* c. no 9a. *5.0 m/s² [E]* b. *2.5 s* 10a. *$2.86 \times 10^7$ N* b. *$4.8 \times 10^6$ N[up]* c. *1.6 m/s²* d. uses up fuel e. increase (because mass decreases) 11. *10.2 m/s², 53.3 m/s²* 12. *49 N[up]* 13. net force is zero (forward push of wind from fan on sails balanced by force of air pushing back on fan) 14. *60 m/s* 15. *$1.6 \times 10^4$ N[S]* 16. *5.0 s* 17. *$1.5 \times 10^4$ N[W]* 18. *44.0 m/s [S]* 19. *18 N[up]* 20. *44 m/s*