Part I

1. When a horse pulls a wagon, the force that causes the horse to move forward is
   (a) the force he exerts on the ground.
   (b) the force he exerts on the wagon.
   (c) the force the ground exerts on him.
   (d) the force the wagon exerts on him.

   Answer (c):This is the only force acting on him in the forward direction.

2. A coin is tossed vertically up in the air. It first rises and then falls. As the coin passes through its highest point the net force on it
   (a) becomes zero.
   (b) acts downwards and reaches a maximum value.
   (c) acts downwards and reaches a minimum value.
   (d) acts downwards and remains constant.

   Answer (d): The force due to gravity acts downwards and is constant.

3. A helicopter flies horizontally with constant velocity. The net force acting on it is
   (a) parallel to the velocity.
   (b) vertically upward.
   (c) vertically downward.
   (d) zero.

   Answer (d): Velocity is constant so the net force is zero by Newton's 1st Law

4. A constant force is exerted on a cart that is initially at rest on a track. Friction between the cart and the track is negligible. The force acts for a short time interval and gives the cart a certain final speed. To reach the same final speed with a force that is only half as big, the force must be exerted on the cart for a time interval
   (a) four times as long as for the stronger force
   (b) twice as long as for the stronger force
   (c) half as long as for the stronger force
   (d) a quarter as long as for the stronger force

   Answer (b): If the force is half as big but the mass is the same then the acceleration is half as big so it takes twice as long to reach the same velocity.

5. A constant force is exerted for a short time interval on a cart that is initially at rest on frictionless track. This force gives the cart a certain final speed. The same force is exerted for the same length of time on another cart, also initially at rest, that has twice the mass of the first one. The final speed of the heavier cart is

   (a) one-fourth that of the lighter cart
   (b) half that of the lighter cart
   (c) the same as that of the lighter cart
   (d) double that of the lighter cart

   Answer (b): If the force is the same but the mass is double then the acceleration is half. So if the time interval is kept the same than the change in velocity is half.

6. A rocket of mass 10000 kg on the surface of the earth accelerates upward at a rate of 4 m/s^2. The force provided by the rocket engines must be

   (a) 40000 N (b) 100000 N (c) 140000 N (d) 160000 N

   Answer (c): Call the upward force T for thrust. $F_{\text{net}} = T - W = ma \;\Rightarrow\; T = W + ma = mg + ma \approx 140000$ N.

7. A big ship crashes into a small canoe. During the collision the force that the ship exerts on the canoe is

   (a) greater than the force the canoe exerts on the ship.
   (b) equal to the force the canoe exerts on the ship.
   (c) less than the force the canoe exerts on the ship.
   (d) is related to the force on the canoe in a way that depends on the nature of the collision.

   Answer (b): By the Newton'w 3rd law. The acceleration of the canoe will be much larger.

8. A mass of 30kg on a smooth horizontal table is tied to a cord running along the table over a frictionless pulley mounted at the edge of the table. A 10kg mass is attached to the other end of the cord. When the two masses are allowed to move freely the tension in the cord is

   (a) 300 N. (b) 150 N. (c) 100 N. (d) 75 N.
   Answer (d)

9. A stationary book sits on a table. Newton's third law is often stated as "To every *action* there is an equal and opposite *reaction*". The reaction to the weight of the book is the force that the

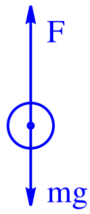
   (a) earth exerts on the book.
   (b) book exerts on the table.
   (c) table exerts on the book.
   (d) book exerts on the earth.

   Answer (d): The weight is the force the earth exerts on the book so the reaction to the weight must be the force the book exerts on the earth.

Part II

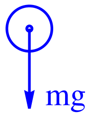
1. A basketball player is jumping vertically upward in order to land a shot. Her legs are flexed and pushing on the floor so that her body is accelerated upward.

   (a) Draw a free-body diagram of the player. Show the relative magnitudes of the various forces and describe each in words .

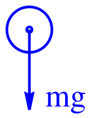
   F is the reaction force of the ground pushing up on her feet and mg is her weight acting down

   (b) Repeat this exercise for the situation immediately after the player's body breaks contact with the floor.

   The only force acting on her is her weight.

   (c) Finally, consider, in the same manner, the situation at the top of the jump.

   The only force acting on her is her weight.

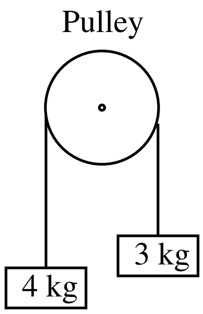
2. A toy is dragged along a rough floor by a child.

   (a) When the child applies a force of 0.50N horizontally the velocity is constant at 1.0 m/s. What is the force of friction on the toy?
   Since velocity is constant $F_{\text{net}} = 0$ so $f_k = 0.5N$.

   (b) When the child pulls harder so that the applied force is 1.00 N the velocity of the toy increases uniformly to 2.0 m/s in 5.0 seconds. Calculate the acceleration of the block
   $$a = \frac{\Delta v}{\Delta t} = \frac{2-1}{5} = 0.2 \text{ m/s}^2$$

   (c) Find the mass of the toy.
   $$m = \frac{F_{\text{net}}}{a} = \frac{1.0-0.5}{0.2} = 2.5 \text{ kg}$$

3. Atwood's Machine.



The set up illustrated in the diagram on the left consists of two blocks connected by a string which passes over a frictionless (and massless) pulley. (The string, by the way, is massless too – you can get these in the same place you buy the pulley above.)

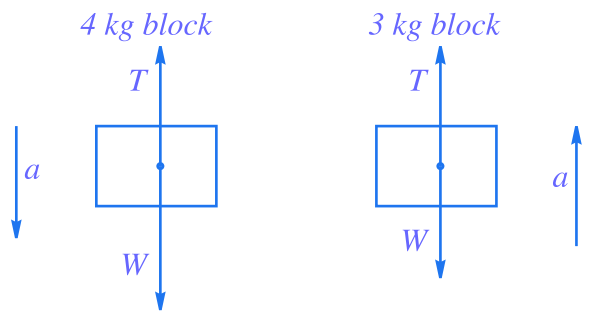
(a) The 3 kg weight is initially held still so that the system is stationary. What is the tension in the string at this time.

If the system is stationary then $F_{\text{net}} = 0$ and so tension is equal to the weight of the 4 kg block. $T = W = mg = 4 \times 9.8 = 39.2$ N.

(b) The weight is then released. Does the tension in the string stay the same, get smaller or get larger?

Since the 4 kg block will accelerate downward the force in the downward direction will exceed the upward force of tension. Therefore the tension will get smaller.

(c) To answer the question in part (b) quantitatively, draw free body diagrams for each block separately. Then write down an expression for the net force on each assuming tension is an unknown quantity T. Apply Newton's second law in each case. Hence find the acceleration of the blocks and the tension in the string.



For the 4 kg block acceleration is downward so $F_{\text{net}} = W - T = 39.2 - T$ and Newton's second law states $F_{\text{net}} = ma = 4a$ so we have $39.2 - T = 4a$. Similarly for the 3 kg block the acceleration is up so $F_{\text{net}} = T - W = T - 29.4 = 3a$. It is easiest to solve these simultaneous equations by elimination. Adding the equations together eliminates T and gives $39.2 - T + T - 29.4 = 4a + 3a \;\Rightarrow\; 9.8 = 7a \;\Rightarrow a = 9.8/7 = 1.4$ m/s^2. Now substituting this value of a into either equation gives $T = 33.6$ N. This is less than the weight of the 4 kg block and more than the weight of the 3 kg block.