Part I

1. 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.

2. 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

3. A rocket of mass 10000 kg is 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.

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 half then the acceleration is half. So if the time interval is kept the same than the change in velocity is half.

6. A crate is moving to the right on a conveyor belt without slipping. The conveyor belt maintains a constant speed. The force of friction on the crate is

   (a) to the right

   (b) to the left

   (c) zero

   (d) first to the right then to the left.

   Answer (c): Constant speed means the net force on the crate is zero so the force of friction on the crate is zero. If the crate had been accelerating then friction would have acted to the right.

Part II

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

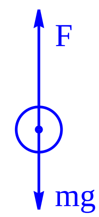
   (a) When the child applies a force of 0.50N horizontally the velocity is constant at 1.0 m/s. What is the force of friction on the toy?
   Since velocity is constant $F_{\text{net}} = 0$ so $f_k = 0.5N$.

   (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.
   $$m = \frac{F_{\text{net}}}{a} = \frac{1.0-0.5}{0.2} = 2.5 \text{ kg}$$

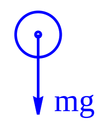
2. A basketball player is jumping vertically upward in order to make a shot at the basket. Initially her knees are bent and then she pushes against with a constant force so that her body is accelerated upward.

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



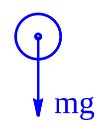
   F is the reaction force of the ground pushing up on her feet and mg is her weight acting down

   (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.

   (d) The the player has a mass of 70 kg. Suppose she accelerates upward at a rate of 11.2 m/s^2 while she is pushing off the ground and this phase of the jump takes 0.5 seconds.

      (i) With what force does she push off the ground?
      The force with which she pushes off the ground is equal to the Normal force and since $F_{\text{net}} = N - W$ and Newton's second law states that $F_{\text{net}} = ma$ it follows that $N - W = ma \;\Rightarrow\; N = W + ma = mg + ma = 70(9.8) + 70(11.2) = 1470$ N

      (ii) What is her velocity when her feet first leave the ground?
      For uniformly accelerated motion $\Delta v = at = 11.2 \times 0.5 = 5.6$ m/s. So this is her speed as she leaves the ground

      (iii) How high does she jump?
      After she leaves the ground her acceleration is uniform an downward $a = 9.8$ m/s^2. Using $v^2 = v_0^2 + 2a\Delta y$ with $v = 0$ at the top of the jump and $v_0 = 5.6$ m/s. That $\Delta y = (5.6)^2/(2 \times 9.8) = 1.6$ m