

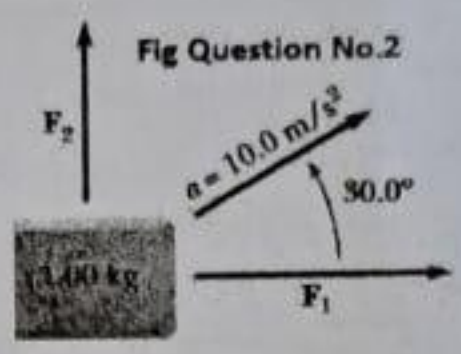
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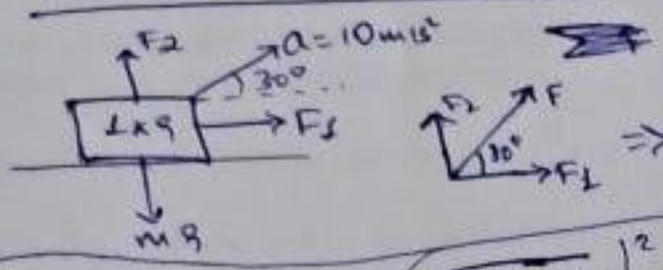
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6. A 1.00-kg object is observed to have an acceleration of 10.0 m/s² in a direction 30.0° north of east (Fig. Question No .2). The force F_2 acting on the object has a magnitude of 5.00 N and is directed north. Determine the magnitude and direction of the force F_1 acting on the object?



free body diagram

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$\Sigma F = ma \Rightarrow F = \sqrt{F_2^2 + F_1^2}$

$F = ma \Rightarrow \left(\sqrt{F_2^2 + F_1^2}\right)^2 = (1 \times 10)^2 \Rightarrow F_2^2 + F_1^2 = 100$

$\Rightarrow F_1^2 = 100 - 5^2$

$F_1 = \sqrt{100 - 25}$

$F_1 = \sqrt{75} = 8.66N$

1.75

7. Two objects with masses of 3.00 kg and 5.00 kg are connected by a light string that passes over a light frictionless pulley to form an Atwood machine, as in Figure Question No 3. Determine (a) the tension in the string, (b) the acceleration of each object,

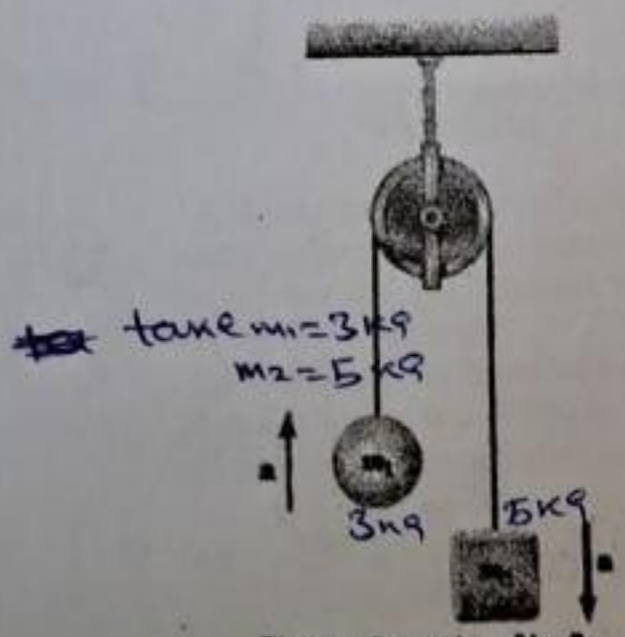
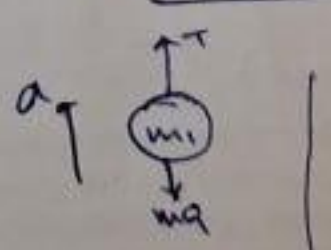


Figure Question No.3

→ free body diagram



1.75

$\Sigma F_y = m_1 a$ | $\Sigma F_y = m_2 a$

$T - m_1 g = m_1 a$ | $m_2 g - T = m_2 a$

$T - 30 = 3a$ (1) | $50 - T = 5a$ (2)

⇒ solve (1) and (2)

$T - 30 = 3a$

$50 - T = 5a$

$20 = 8a$

$a = \frac{20}{8} m/s^2$ $a = 2.5 m/s^2$

$T - 30 = 3(2.5)$

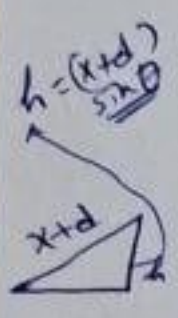
$T = 37.5 N$

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8. An inclined plane of angle $\Theta=20^\circ$ has a spring of force constant $k = 500$ N/m fastened securely at the bottom so that the spring is parallel to the surface as shown in Figure to the right. A block of mass $m = 2.50$ kg is placed on the plane at a distance $d = 0.300$ m from the spring. From this position, the block is projected downward toward the spring with speed $v = 0.750$ m/s. By what distance is the spring compressed when the block momentarily comes to rest?





using conservation of energy

$E_0 = E_f$

$W + PE_0 + KE_0 = PE_f + KE_f + E_{lost}$

$\Rightarrow mgh + \frac{1}{2}mv^2 = \frac{1}{2}kx^2$

$\Rightarrow 25h + \frac{1}{2}(2.5)(0.75)^2 = \frac{1}{2}(500)(x)^2$

$\Rightarrow 25(x+d)\sin 20 + \frac{1}{2}(2.5)(0.75)^2 = \frac{1}{2}(500)x^2$

multiply all by 2

$\Rightarrow 50(x+0.3)\sin 20^\circ + (2.5)(0.75)^2 = 500x^2$

$\Rightarrow 17(x+0.3) + 1.4 = 500x^2$

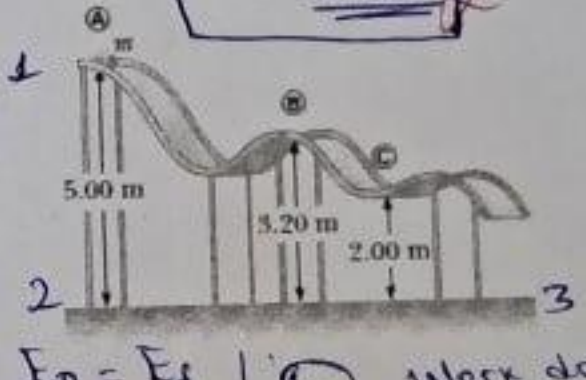
$\Rightarrow 500x^2 - 17x - 5.1 - 1.4 = 0$

-6.5

using $x = \frac{-b \pm \sqrt{b^2-4ac}}{2a}$

$\boxed{x = 0.13\ m}$

9. A block of mass $m = 5.00$ kg is released from point A and slides on the frictionless track shown in Figure to the right. Determine



(a) The block's speed at points B and C and

(b) The net work done by the gravitational force on the block as it moves from point A to point C

Solution

a) using conservation of energy $\Rightarrow E_0 = E_f$

$W + PE_0 + KE_0 = PE_f + KE_f + E_{lost}$

$mgh_1 = mgh_2 + \frac{1}{2}mv^2$

$v^2 = \frac{2(mgh_1 - mgh_2)}{m}$

$v = \sqrt{2g(h_1 - h_2)}$

$\therefore$ at $h_2 = 3.3$ $\quad v = \sqrt{2(10)(5-3.2)} = \sqrt{36} = 6$ m/s at point B

at point C or $h_3 = 2$ m $\quad v = \sqrt{20(5-2)} = \sqrt{60} = 7.7$ m/s

b) Work done is path independent so.

$\Rightarrow W_{12} = mgh$ from $\int_2^5$ $\quad \Delta h = 3$

$\Rightarrow 5 \times 10 \times 3 = 150$ N

$W_{23} = mg.s\cos\theta$ from $\quad W = 0 \quad \sin\theta = 0$

$W_T = W_{12} + W_{23} = 150 + 0$

$\boxed{W_T = 150\ N}$

10. A single conservative force acting on a particle within a system varies as $\vec{F} = (-\alpha x^2 + \beta x^3)\,\mathbf{i}$, where α and β are constants, **F** is in newton's, and x is in meters.
Based on this, (a) Calculate the potential energy function $U(x)$ associated with this force for the system, taking $U = 0$ at $x = 0$.
(b) The change in potential energy and the change in kinetic energy of the system as the particle moves from $x = 2.00$ m to $x = 3.00$ m.
(c) Is this force conservative or not? Justify you answer.

a) $U = -\int f\,dx = -\int (-\alpha x^2 + \beta x^3)\,dx \Rightarrow -\left(-\frac{\alpha x^3}{3} + \frac{\beta x^4}{4}\right) = -\frac{\beta x^4}{4} + \frac{\alpha x^3}{3}$

$\Rightarrow \therefore U = -\frac{\beta x^4}{4} + \frac{\alpha x^3}{3} + U_0$

b) $U = -\int_2^3 f\,dx \Rightarrow \left.\frac{-\beta x^4}{4} + \frac{\alpha x^3}{3}\right|_2^3 \Rightarrow \left(\frac{-\beta 3^4}{4} + \frac{\alpha 3^3}{3}\right) - \left(\frac{-\beta 2^4}{4} + \frac{\alpha 2^3}{3}\right)$

$\Rightarrow \Delta KE = -\Delta U$ from $\Delta E_{system} = \Delta KE + \Delta U + \Delta E_{int}$

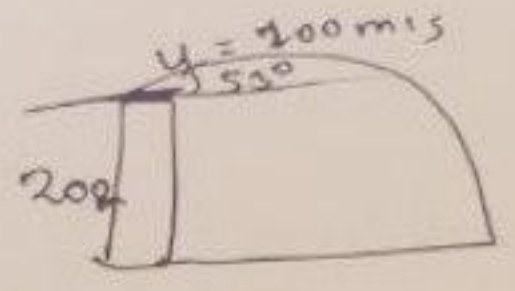
c) $\Delta KE = -\Delta U \therefore$ the force is Conservative

5

PART III: WORKOUT ITEMS

Direction: Solve the following problems by showing all the necessary steps briefly only in the space provided [10%, 5points for each question]

1. A man throws a ball upward from the top of a building 200 m above the ground level with an initial speed of 100 m/s at an angle of 53° above the horizontal. Calculate
   a) How long does it take the ball to reach the ground? = t
   b) What is the speed of the ball just before it strikes the ground? V = ?
   c) The horizontal distance traveled from the base of the building x = ?
   (Use: $\sin 53° = 0.8$, $\cos 53° = 0.6$, $g = 10\ m/s^2$)



$u_{0x} = u_0 \cos\theta$
$= 100 \times 0.6$
$= 60\ m/s$

$u_{0y} = u_0 \sin\theta$
$= 100 \times 0.8$
$= 80\ m/s$

$y = -200$, $y_0 = 0$, $u_{0y} = 80 m/s$, $t = ?$, $g = -10 m/s^2$

a. $y = y_0 + u_{0y} t + \frac{1}{2} g t^2$

$-200 = 0 + 80(t) - (10 m/s^2)(t)^2$

$-200 = 80t - 10t^2$

$-200 - 80t + 10t^2 = 0$

$t = 10\ sec$

$= \frac{-b \pm \sqrt{b^2 - 4ac}}{2a}$

$= \frac{80 \pm \sqrt{(80)^2 - 4(10)(-200)}}{2(10)}$

$= \frac{80 \pm \sqrt{6400 + 8000}}{20}$

$= \frac{80 \pm \sqrt{14400}}{20}$

$= \frac{80 \pm 120}{20}$ $= 10, 0.2$ ✗

$80t = 10$

b. $u_{0x} = v_x = 60 m/s$

$v_y = u_{0y} + gt$

$= 80 - 10(10)$

$v_y = 80 - 100 = -20$

$v = \sqrt{(60)^2 + (-20)^2}$

$\sqrt{3600 + (400)}$

$\sqrt{4000} = 63.2\ m/s$

$\tan\theta = \frac{v_y}{v_x}$: $\theta = \tan\left(\frac{-20}{60}\right) = 0.33$

but $\theta = 18.2°$ below the building

c. $x = u_{0x} t$

$= 60 \times 10 = 600\ m$

25

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Part III: WORK OUT PROBLEMS (17.5pts)

1. As soon as a traffic light turns green, a car speeds up from rest to 50.0 mi/h with constant acceleration 9.00 mi/h/s. In the adjoining bicycle lane, a cyclist speeds up from rest to 20.0 mi/h with constant acceleration 13.0 mi/h/s. Each vehicle maintains constant velocity after reaching its cruising speed.

(a) For what time interval is the bicycle ahead of the car?

(b) By what maximum distance does the bicycle lead the car?

1.5

50 m

$v_c = 0$
$v_c = 5\,mi/h$
$a_c = 9\,mi/h/s$
$v_b = 0$
$v_c = 20\,mi/h$
$a_c = 13\,mi/h/s$

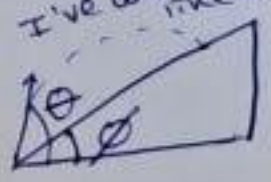
a) $v^2 = u^2 + 2as \Rightarrow t = \frac{50}{9} = 1.5\,sec$

$s = \frac{v^2}{2a} = \frac{s^2}{2(9)} = \frac{2500}{18} = 139\,m$

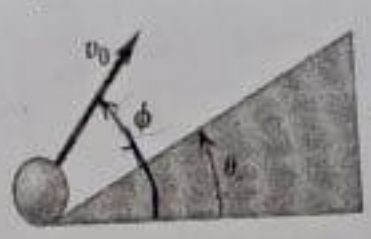
$s_2 = \frac{v^2}{2a} = \frac{(20)^2}{2(13)} = \frac{400}{26} = 15\,m$

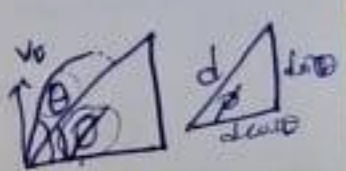
b) $s_c - s_b = 139 - 15\,m = 123\,m$ (maximum distance)

I've consider it like this



Launching a ball from an inclined ramp.





2. You fire a ball with an initial speed at an angle Θ above the surface of an incline, which is itself inclined at an angle of φ above the horizontal as shown in the Figure to the Right
(a) Find the distance, measured along the incline, from the launch point to the point when the ball strikes the incline.
(b)What angle φ gives the maximum range, measured along the incline? Ignore air resistance.

a) $y = \tan\theta\, x - \left(\frac{g}{2v_0^2\cos^2\theta}\right)x^2$

$\Rightarrow \frac{d\sin\phi}{d} = \frac{\tan\theta\, d\cos\phi}{d} - \frac{g\,d^2\cos^2\phi}{2v_0^2\cos^2\theta}$

$\Rightarrow \sin\phi = \tan\theta\cos\phi - \frac{gd\cos^2\phi}{2v_0^2\cos^2\theta}$

use $\sin(\theta+\phi) = \sin\theta\cos\phi + \cos\theta\sin\phi$

$\Rightarrow \frac{gd\cos^2\phi}{2v_0^2\cos^2\theta} = \frac{\sin\theta}{\cos\theta}\cos\phi - \sin\phi$

$\Rightarrow \frac{\sin\theta\cos\phi - \sin\phi\cos\theta}{\cos\theta}$

$\Rightarrow \sin(\theta-\phi)$

$$d = \frac{2v_0^2\cos^2\theta\,[\sin(\theta-\phi)]}{g\cos^2\phi}$$

to make d maximum.

$$d = \frac{2v_0^2\cos^2\theta\,[\sin\theta - \phi]}{g\cos^2\phi}$$

we take θ to be 45°

1.75

3. An athlete swings a ball, connected to the end of a chain, in a horizontal circle. The athlete is able to rotate the ball at the rate of 8 rev/s when the length of the chain is 0.600 m. When he increases the length to 0.9 m, he is able to rotate the ball only 6 rev/s.
(a) Which rate of rotation gives the greater speed for the ball?
(b) What is the centripetal acceleration of the ball at 8rev/s?
(c) What is the centripetal acceleration at 6 rev/s?

1.75

Given
$r_1 = 0.6$ $\omega_1 = 8\,rev/s$
$r_2 = 0.9$ $\omega_2 = 6\,rev/s$

Req
a) V_1 and V_2
b) a_{c_1} at ω_1
c) a_{c_2} at ω_2

Soln

a) $V = \omega r \Rightarrow V_1 = \omega_1 r_1 = 8 \times 0.6 = 4.8\,m/s$
$V_2 = \omega_2 r_2 = 0.9 \times 6 = 5.4\,m/s$

∴ The second (2nd) rotation gives the greater speed $V_2 > V_1$
$5.4 > 4.8$

b) $a_c = \frac{V^2}{r} = \frac{(\omega r)^2}{r} = \frac{\omega^2 r^2}{r} = \omega^2 r$

$a_{c_1} = 8^2 \cdot 0.6 = 38.4\,m/s^2$

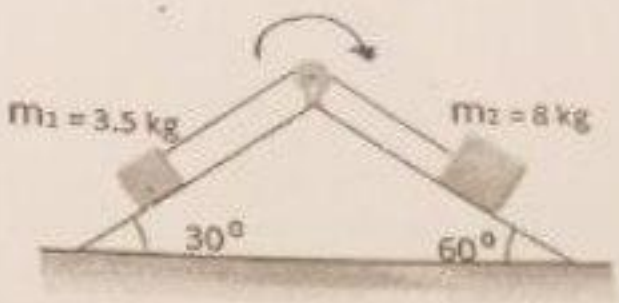
c) $a_{c_2} = \omega^2 r = 6^2 \cdot 0.9 = 32.4\,m/s^2$

(2)

Two blocks of Masses m_1=3.5 kg and m_2 = 8 kg are connected by a massless string that passes over a frictionless pulley as shown in the figure below. The coefficient of friction between the incline and the block is 0.25.

a) Draw free body diagram.
b) The acceleration of the masses
c) The tension in the string.

(Use: g = 10 m/s², sin30° = 0.5, cos30° = 0.86, sin60° = 0.86, cos60° = 0.5)



Given- μ_k = 0.25

(a) For m_1: F_N, $mg\sin\theta$, f_{s_1}, T, $mg\cos\theta$

For m_2: F_N, T, f_{s_2}, $mg\sin\theta$, $mg\cos\theta$

Or

$\Sigma F_y = 0 : F_N - mg\cos\theta = 0$

$F_N = mg\cos\theta$

(b) $\Sigma F_x = m_1 a$

$T - mg\sin\theta - \mu F_N = m_1 a$

$-mg\sin\theta - \mu mg\cos\theta = m_1 a$

$mg\sin\theta - \mu mg\cos\theta = m_2 a$

$-3.5\times0.5\times10 - 0.25\times(3.5)(10)(0.86) = 3.5a$

$8\times10\times0.86 - 0.25\times(8)(10)(0.5) = 8a$

$-17.5 - 7.525 = 3.5a$

$68.8 - 10 = 8a$

$-25.025 = 3.5a$

$58.8 = 8a$

$33.775 = 11.5a$

$a = 2.93\ m/s^2$

(c) $T - mg\sin\theta - \mu F_N = m_1 a$

$T = mg\sin\theta + \mu F_N + m_1 a$

$T = 3.5\times10\times0.5 + 0.25\times3.5\times10\times0.8$

$T = 25.025$

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22/25 Good!!

COLLEGE OF APPLIED SCIENCES

DEPARTMENT OF PHYSICS AND STATISTICS

General Physics (Phy2003) Test I (25%) **Time allowed** **2 Hrs** **Sept 1, 2023**

Name: Tesfamichael Tafere **ID.No.** 1303/15 **Section** 1A

Part I: Fill in the blank spaces with the correct answers (4pts)

1. A car traveling at a constant speed of 45.0 m/s passes a trooper on a motorcycle hidden behind a billboard. One second after the speeding car passes the billboard; the trooper sets out from the billboard to catch the car, accelerating at a constant rate of 3.00 m/s2. The trooper Will then take 31 sec time long to overtake the car?

2. A pebble is released from rest at a certain height and falls freely, reaching an impact speed of 4 m/s at the floor. Next, the pebble is thrown down with an initial speed of 3 m/s from the same height. Its speed at the floor is 5 m/s.

3. A cannon with a muzzle speed of 1000 m/s is used to start an avalanche on a mountain slope. The target is 2000 m from the cannon horizontally and 800 m above the cannon. The cannon is fired at an angle of 21.7° above the horizontal?

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4. A firefighter, a distance d from a burning building, directs a stream of water from a fire house at angle Θ_i above the horizontal. If the initial speed of the stream is v_i, the water will strike the building at a height of 0.77 m.

$$(d,h) \Rightarrow y = \tan\theta_i \cdot d - \left(\frac{g}{2v_i^2\cos^2\theta_i}\right)d^2$$

$$\Rightarrow h = \tan\theta_i \cdot d - \frac{9d^2}{2v_i^2\cos^2\theta_i}$$

5. A horizontal force of _____ N must be applied to a large block of mass M shown in Figure right, so that the two blocks m_1 and m_2 remains stationary relative to M? Assume all surfaces and the pulleys are frictionless. Notice that the force exerted by the string accelerates m_2.



$$\Rightarrow F = (M + m_1 + m_2)\left(\frac{m_1 g}{m_2 - m_1}\right)$$ 0.25

Part II: Give a short and precise explanation for the following questions (4pts)

1. State the **Newton's law of gravitation** and justify the statements of Kepler's **law** of planetary motions **(2.5pts)**

✓ If any two masses m_1 and m_2 are r distance apart from each other there is a force F bin them that make them attract each other. $F = G\frac{m_1 m_2}{r^2}$

✓ Kepler's Law of planetary motions is about the orbital and elliptical motion of planets around the sun. that is if sun is at one foci and the planets at the end points ellips then $PF_1 + PF_2 = 2a$

also kepler said that $A_1 = A_2$ ✓



2. Explain the difference between **Conservative** and **Non - conservative** forces with examples for each class **(1.5pt)**

✓ Conservative force is a force that is conserved in each point of the motion and always has the same magnitude in the initial and the final position. Eg!- gravitational force

✓ Non conservative force is also called dispative force due to the abondance of some energy impact from the system - into heat energy, sound energy, drage force etc

eg!- frictional force, 1- air (drag force)

(1)

PART I: FILL IN THE BLANK SPACE ITEMS

Direction: Fill in the blank space with the most simplified answers [6%, 1pt for each blank space]

1. For the three vectors, $A = 3i + 4j + 5k$ and $B = 6i + 8j + 10k$ find
   a) $A \cdot B =$ 100
   b) A unit vector having magnitude 4 times B and a direction perpendicular to both vectors
   $A \times B =$ $\frac{24i + 32j + 40k}{14.14}$
2. An airplane moving horizontally at a height of 500m releases a heavy bomb to hit a target at a horizontal distance of 1000m. The initial velocity of the plane to hit the target is 99.10 m/s
3. The coordinates of a bird flying in the xy-plane are given by $x(t) = at + b$ and $y(t) = ct^2 + d$, where $a = 1.00\ m/sec$, $b = 1.00\ m$, $c = 0.125\ \frac{m}{sec^2}$, and $d = 1.00\ m$
   a) The speed of the bird at t = 5.0s is 6 m/s, 4.125 m/s — for x, for y
   b) The average velocity between t =1 sec and t = 3sec = 2 m/s, 1 m/s.
   c) The acceleration of the bird for the time interval t = 0 to t = 10s is 0.2 m/s², 0.1 m/s²

PART II: SHORT ANSWER ITEMS

Direction: Give short answers for the following questions only in the space provided [4%, 1.5pt each]

1. Why are action and reaction forces not added to give a zero resultant force equal in magnitude and opposite direction?
   Bic the object or body are dif (only action and reaction forces act on dif object then it doesn't added.
2. An object moves in a circular path with constant speed v.
   a) Is the velocity of the object constant? Explain
   :- No bic the velocity of the object change bic change direction. Or
   ▸ the velocity of the object tangent to the circular path and perpendicular to the radius of the object.
   b) Is its acceleration constant? Explain
   No bic velocity change then acceleration also change. and the acceleration is perpendicular to the circular path and directly toward to the center of the object.

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3. State the following Laws.
   a) Newton's 1st law of motion :- State that : the body will continue at State of rest or uniform motion unless the net force exerted.
   b) Newton's 2nd law of motion :- state that : the acceleration of the object is directly proportional to the net force and inversely proportional to the mass of the object :. $f_{net} = \frac{ma}{m}$