

hello everyone and welcome to this session of solving the problems in this session we will solve the problems on laws of motion

so let's start with our first problem our first problem is a block of mass 2 kg placed on a long frictionless horizontal table is pulled horizontally by a constant force f it is found to move 10 meter in the first two seconds then find the magnitude of the applied force let's solve this first see what are the different values of the parameters provided here we are provided with mass m which is equal to 2 kg distance traveled by the body s is 10 meter initial velocity u was zero because the body was at rest and time taken in traveling this distance 10 meter was two seconds

so these values are provided and we have to calculate the magnitude of the force that was applied on the body for this let's start with this equation which is $s = ut + \frac{1}{2}at^2$ which tells us about the distance in terms of velocity time and acceleration that is s is equal to ut plus half $a t^2$ we know that initial velocity of the body was zero

so this first term here will be 0 and we are left with the second term only so the displacement can be written like $\frac{1}{2}at^2$ and here putting the values of s and t we can calculate the acceleration we already know the value of s that is 10 meter and t is 2 seconds

so the value of acceleration comes out to be 5 meter per second square now we know the acceleration and we already know the mass of the body

so we can calculate using this formula a is equal to f by m or f is equal to ma this is the second law of newton from here putting the values of mass and acceleration in this relation we can calculate the force that comes out to be 10 newton

so 10 newton is the force that was applied on the body to drag it by 10 meter in two seconds

so this is our answer of this problem now let's move to the second question our second problem is a shape of mass 2×10^7 kg initially at rest is pulled by a force of 7×10^5 newton through a distance of 3 meter assuming that the resistance due to water is negligible calculate the speed of the shape for solving this problem first see what are the values that are provided here in this problem and we see that mass is provided m that is equal to 2×10^7 kg force is provided f that is 7×10^5 newton initially the ship was at rest so initial velocity u will be equal to zero distance traveled as is three meter and we have to calculate the final velocity for calculating the final velocity we can use this formula which is $v = u + at$ u is the initial velocity a is the acceleration and t is the time taken we know that initial velocity u is 0

so we can write $v = at$ here acceleration the value of acceleration is not provided the value of time is also not provided

so we have to convert these things or we have to rewrite these parameters in terms of the values that are provided in the problem for this we can write a in terms of force and mass using this relation this is the second laws of newton and if we write acceleration in this form then we can write velocity is equal to force by mass into time again we have to write this time in terms of the known parameters and for this we can use this relation that is $s = ut + \frac{1}{2}at^2$ or displacement equal to ut plus half $a t^2$ here because the initial velocity was 0

so this term is again 0 and we are left with the $s = \frac{1}{2}at^2$

so from here we can write the time in terms of displacement and acceleration and if we further write this acceleration in terms of force and mass that

are the known parameters and we put this value of t in the relation of b is equal to 80 that we have discussed before in previous equation then we can write the final velocity in this form that is square root 2 times displacement times force divided by mass putting the values of all these these three parameters as f and m we can calculate the velocity from this relation and it comes out to be 0.45 meter per second

so this is the the final answer this is the final velocity that was attained by the shape when it was dragged by a distance s and by the given force that was applied on the ship now let's move to another problem our next problem is a block of mass m slides along a floor while a force of magnitude f is applied to it at an angle as shown in the figure the coefficient of kinetic friction is μ then what will be the value of acceleration of the block

so first let's understand this problem using this diagram

so this is the body of mass m and it is sitting on this surface where the coefficient of kinetic friction between the body and the surface is μ we are applying here a force f on the body at an angle θ with this plane to solve this type of problem first let's understand all the different type of forces that are acting on this body from different directions

so here we can see we are applying the force at this angle θ with respect to this plane

so we can split it into two components one is along this surface that will be $f \cos \theta$ and one is perpendicular to the surface that is $f \sin \theta$ on the body there will be another force perpendicular to this surface that will be the reaction force defined here as n and another force that will act downward that is because of the weight that is mg and one force because we are saying the body will move

so one force will be the frictional force that will be in this side that is opposite to the component of this force and that is defined here as f now let's see what will be the values of these different forces and how they will relate with each other

so n here because there are two forces acting on the upper side perpendicular to the surface and one force is acting on the downward side

so if we take these forces then from these three forces we can say for the equilibrium state because the body is not moving in this direction or in the downward direction

so n will be equal to $mg \sin \theta$ and for moving the body in this direction because we are applying the force in in along this direction and we are applying the force $f \cos \theta$ this is the component of the force that is acting along this direction

so if it is moving then it must be $f \cos \theta - f$ equals to m times the acceleration f is the frictional force the value of frictional force can be calculated using μ that is the coefficient of friction times reaction force that is n value of n is already defined here in the relation one which comes out to be $mg \sin \theta$ and taking this value of f and putting it in this equation 2 we can calculate the value of a as $f \cos \theta - \mu (mg \sin \theta)$ from here we can write it in other way like a is equal to $f \cos \theta - \mu (mg \sin \theta)$ in this problem the values of force mass or θ were not provided

so we can write acceleration in this form and this is our final answer our next problem is a block of mass 4 kg rests on a rough inclined plane making an angle of 30 degree with the horizontal the coefficient of a static friction between the block and the plane is 0.7 then calculate the frictional force acting on the block

so let's understand this again using the block diagram

so here this is our inclined plane this is the 30 degree the plane and the here is our body whose mass is given as the 4 kg

so this will be the component of the force because of the gravity and mass this will be equal to mg here and this will be the reaction force because it's resting on this surface

so it will be normal to this surface and we can see that this force we can split into two components one is perpendicular to this surface on which the body is resting that will be $mg \cos \theta$ because this angle will be equal to this angle this relation we can find using the simple trigonometry and another component of this force mg will be along this plane that will be $mg \sin \theta$

so this component that is $mg \sin \theta$ may result in moving of this or sliding of this this block in this direction that is downward direction but there is another force acting on the opposite direction that is the frictional force

so as given in the problem this body is at rest it's not moving down so in that case there must be a equilibrium and under the equilibrium we can define it as the force that is the frictional force that is acting on the upper direction must be equal to the force that is acting on the downward direction

so if we put the value of m , g and θ here in this relation then we can using this simple relation we can calculate the value of this frictional force that is acting on the upward direction will be 4×9.8 that is the value of g into half that is the value of $\sin 30^\circ$ degree and the final answer will be 19.6 newton this is the value of the frictional force acting on the upward direction

so that particle will stay at rest on the inclined surface after this let's move to another problem our next problem is the pulleys and strings shown in the figure are smooth and of negligible mass for the system to remain in equilibrium what should be the value of angle θ

so let's understand this problem here we have two masses of mass m each one is here and another one is here and the third mass our next problem is the pulleys and strings shown in the figure are smooth and of negligible mass for the system to remain in equilibrium what should be the value of angle θ

so let's first understand this problem we have three bodies one here that is of mass m another one is here that is of also the same value of mass that is m and third body is here that is of mass $\sqrt{2}m$ they all are tied with the strings of our next problem is the pulleys and strings shown in the figures are smooth and of negligible mass they are shown here in this figure for the system to remain in equilibrium what should be the value of angle θ

so let's understand first this problem which is shown here in terms of these block diagrams that we have here three bodies one is here that is of mass m another one is here that is of mass m and third body is here that that has the mass $\sqrt{2}m$ these all three bodies are tied with two strings they are inextensible strings and the pulleys are frictionless or smooth here this is the angle with respect to this plane this angle is θ and considering that this whole system is in equilibrium state we have to find the value of this angle θ

so as similar to what we did in the previous problems or the questions here again first we will identify all the forces and their directions acting on all these three bodies and after knowing the forces we will solve our problem so here we can see different forces acting on these bodies first we can see this is the tension here tension in the string because this body is tied with

this string and this is an equilibrium
 so this tension in the string will be equal to the mass into gravity that is
 the force due to gravity here on this body
 so we can say this T_1 will be equal to mg this body also has the same mass
 so tension in this string will all T_2 will also be equal to mg now let's see
 the third body that has the mass $\sqrt{2}m$
 so this body is tied with two strings this and this one because the system is
 in equilibrium
 so tension in this part of the string will be same but in opposite direction
 to the tension on this part
 so that will be T_1 but it will be acting in the opposite direction similarly
 in this part of the string there will be a tension T_2 which is the the
 tension that is acting here but it will act in the opposite direction of this
 tension that is acting in this part of the string the net component of these
 string these two tensions because we can split it into two parts as they are
 acting at a angle with respect to this plane
 so one component of this tension will be $T_1 \cos \theta_1$ and the one component
 of this tension will be $T_2 \cos \theta_2$ that will act in this direction that is
 perpendicular to the surface of this body
 so we can write it like this because it's again in we we know that this is the
 equilibrium system
 so the addition of these two components that is $T_1 \cos \theta_1$ plus $T_2 \cos$
 θ_2 must be equal to the the component of force or the force that is coming
 because of the mass and gravity that is $\sqrt{2}m$ into g further we
 know there will be another component of this tension along this surface that
 will be $T_2 \sin \theta_2$ and in this direction also there will be one component
 of this tension that will be $T_1 \sin \theta_1$ and the body is not moving in
 this direction or this direction that is left or right
 so both of these forces must be equal to each other
 so we can say $T_1 \sin \theta_1$ is equal to $T_2 \sin \theta_2$ let's say these
 equations as equation 1 2 and 3 from equation 1 and 3 this one and this
 one we can say $mg \sin \theta_1$ is equal to $mg \sin \theta_2$ or because mg
 will be cancelled out from both the sides
 so we can say θ_1 is equal to θ_2 both these angles must be equal for
 the equilibrium state that thing we know after this these equations and
 further because we have to find the value of θ
 so if we use the value of this θ_1 is equal to θ_2 let's say this is the
 relation or equation 4. and 1 that is T_1 is equal to mg and T_2 is equal to mg
 if we put these values from 1 and 4 in this relation that is defined as
 equation 2 then we can write this equation 2 again as $mg \cos \theta$ plus mg
 $\cos \theta$ is equal to $\sqrt{2}mg$ or because m will be cancelled out
 from both the sides and this will be simply $2 \cos \theta$
 so we can write $2 \cos \theta$ is equal to $\sqrt{2}$ or further we can write
 it as $\cos \theta$ is equal to $\frac{1}{\sqrt{2}}$ which is nothing but the value
 of θ for 45 degree
 so our answer is for the equilibrium state of this system the value of θ
 must be 45 degree
 so this is the answer now we move to the next problem next problem is what is
 the maximum value of force F such that the block shown in the arrangement
 doesn't move
 so here as shown in the problem we are applying a force at an angle of 60
 degree with respect to this plane the mass of the body is $\sqrt{3}$
 kilogram it is resting on this surface and here the coefficient of friction is
 $\frac{1}{2\sqrt{3}}$

so let's find out the solution of this problem we can see that there are multiple forces acting on this body one is the downward because of the weight or gravity and one is acting upward perpendicular to this surface that is the reaction force and we are applying this force

so we can split it into two components one is along the surface that will be $f \cos 60^\circ$ because we are applying this force here at an angle of 60° and one component of this force this force f will be downward this will be $f \sin 60^\circ$ we can say that on the upper direction there is a one force n and on the downward direction we have two forces mg and $f \sin 60^\circ$ and there is a no movement in upward or downward direction

so for this equilibrium state n must be equal to mg plus $f \sin 60^\circ$ let's say this is our equation 1 and for body at rest frictional force that is must be equal to $f \cos 60^\circ$ because if we have we are applying a force in this direction that is towards the right side then there must be a force that will be because of the the friction there is a frictional force that will be acting on this direction towards the left side and we know that after applying this force the body is not moving it is at still at the rest so the value of this force component of this force that is $f \cos 60^\circ$ must be equal to the value of the frictional force

so we can say frictional force is equal to $f \cos 60^\circ$ let's say this is our equation two value of frictional force we know we can calculate it using this relation that is coefficient of friction times reaction force μ times reaction force value we can get from equation 1 that is mg plus $f \sin 60^\circ$ degree now using the relation 3 and 1. using the relation sorry using the relation 3 and 2 we can calculate μmg plus $f \sin 60^\circ$ is equal to $f \cos 60^\circ$ degree we can further write it in this form f is equal to μ times m times g divided by $\cos 60^\circ$ minus μ times $\sin 60^\circ$ this is just we are here we are just rearranging these parameters we are taking f on one side and we are we are taking $\cos 60^\circ$ and μ para with new terms on the other side putting the values of μ m g and $\cos 60^\circ$ and $\sin 60^\circ$ we can write it in this form this comes out to be 4.9 divided by $1 - \frac{1}{2}$ minus $1 - \frac{1}{4}$ and the final value of this force comes out to be 19.6 newton

so this is the force the value of force that we are applying here at this angle on this body and under this force the body is still remain at rest because there is a frictional force that is acting in the opposite direction so our final answer here is 19.6 newton that is the value of the applied force

now we move to the next problem our next problem is two particles of mass m each are tied at the end of a light string of length $2a$ the whole system is kept on a frictionless horizontal surface with a string held tight

so that each mass is at a distance a from the center p now the midpoint of the string is pulled vertically upwards with a small but constant force f as a result the particles move towards each other on the surface what will be the value of acceleration when the separation between them is $2x$

so let's first understand this problem

so the problem states that we have two particles m of mass m one is here and another one is here they are tied with a string and here is the center of the string that is say p and the position of particles from the center is q in both the sides now you pull the string from this center by applying a force f in the upward direction after pulling in the upward direction you reach to a state when the separation between the two particles or the two bodies along this horizontal direction become x from the center or $2x$ from each other

so when we reach to this final state then we can say we can see that there are multiple forces will be acting on this system and for solving this

problem we have to know or we have to identify the direction of these forces so first let us start with this point p because on which because on this point we are applying a force f in the onward direction and this point p is actually the midpoint of these two strings and in each of this part of the string there will be a tension t and this is marked here also this is a tension t in this string let's assume there is a plane here passing through this point p and it these strings make an angle theta on this direction and this string makes on this direction with respect to this plane so we can say that this tension t will have two components one is $t \cos \theta$ along this direction that is this is the horizontal direction and $t \sin \theta$ that will be in the the vertical direction downward so both these tensions that is t in this string and t in this string they will have two components in the downward direction that will be $g \sin \theta$ plus $t \sin \theta$ that will be the net downward force and there is a one force only acting in the upward direction f and for the equilibrium state here because this point p will be in the equilibrium we can say f is equal to r r is the net force that is acting in the downward direction that will be equal to $2t \sin \theta$ let's say this is our equation 1 now assume suppose this particle as a system and say what type of forces will be acting on this system then we can see because this is the tension this is the string at an angle with respect to theta from the horizontal plane then there will be one component of this tension that is $t \sin \theta$ will be acting in vertical direction and $t \cos \theta$ will be acting along the horizontal direction there is a one component one force that is acting in the downward direction on this body that is mg because of the weight so here we can say $t \sin \theta$ is equal to mg this will be valid for both the bodies and $t \cos \theta$ will be equal to mass into acceleration this component is coming or this relation is coming because when we are pulling this string from this point with this force f then these two bodies they are also moving along the horizontal plane towards each other and we assume they are moving towards each other with the acceleration a and to produce that acceleration there must be a force acting on these bodies along this direction and that is your $t \cos \theta$ so this $t \cos \theta$ is equal to mass into acceleration from relation one and three one is this and 3 is this we can write $m a$ is equal to f by $2 \cot \theta$ or we can write further it in form of f by $2 m$ that is a a or the acceleration is equal to f by $2 m$ into $\cot \theta$ here we see this angle with resp of the string with respect to this horizontal plane is theta or this angle of the string with respect to theta this angle or this angle they will be same so we know the value of this string the length of this string here from this body to the center that is already defined in the problem this is q and after certain time as defined in the problem this distance from the center of the body to the center of the the the separation between the particles is x then we can calculate the value of $\cot \theta$ we know the value of this r we know the value of this arm and from these q and x we can find the value of $\cot \theta$ or we can write the $\cot \theta$ in terms of these two values that will be x upon square root of q square minus x square so by using this value of $\cot \theta$ we can write your our acceleration in this form again here in this problem the value of any again here in this problem the value of any of these parameters like f to m f m or x or q is not given so we can write acceleration only in this form form we cannot find the exact numerical value of the oscillation here so this will be our final answer our next problem is a block of mass 2 kg slides on an inclined plane which makes an angle 30 degree with the horizontal

the coefficient of kinetic friction between the block and the surface is $\sqrt{3}$ by $\sqrt{2}$. what force should be applied to the block so that it moves a down and b up without any acceleration so first let's solve the case of moving it towards the downside that is our part a

so for moving downward this is our diagram this is the inclined surface that's making an angle 30° with the horizontal plane and here is our body of mass m if we identify the forces acting on this body that are acting in different directions then this is the the force acting in this direction because of the the weight there is a one force acting perpendicular to this surface this is the reaction force and we know that this angle will also be 30° we can get it from the trigonometry this will also be 30° so this force mg can be divided into two components one is in opposite direction of this reduction force that will be $mg \cos 30^\circ$ and one will be along this inclined surface that will be $mg \sin \theta$ suppose here we are applying one force f

so that the body can move downward if it is going to move downward then there will be another force that will be the frictional force that will act in the upward direction that is in direction opposite to the movement so from the direction of all these forces we can see that f plus $mg \sin 30^\circ$ these are the two forces that are acting in the downward direction must be equal to the frictional force okay and frictional force the value of frictional force we know this is always equal to μ that is the coefficient of kinetic friction multiplied by reaction force here again from this this diagram and component of these acting forces we know the traction force will be equal to $mg \cos 30^\circ$ this force

so let's say this is our 3 this is our equation 2 and this is our relation for equation 1 from these 2 and 3 we can write the frictional force like this μ times $mg \cos 30^\circ$ say this is our equation 4 from 1 which is this one and this 4 we can write force this is the applied force equal to $mg \sin \mu \cos 30^\circ$ minus $\sin 30^\circ$ now putting the values of m g and μ that are already given and value of g we know this is 9.8

so putting these values in this relation we can calculate f as 2 into 9.8 into $\sqrt{3}$ by $\sqrt{2}$ into $\cos 30^\circ$ minus $\sin 30^\circ$ and putting the values of $\sin 30^\circ$ and $\cos 30^\circ$ in this relation we get the final value as 10.99 newton

so this is the value of the force that we apply to this body so that it can move in downward direction and this is our answer of this part of the problem now second part of this problem is what will be the value of the force when we move it in the upward direction so in this case the direction of forces will change slightly other component other forces like reaction force due to gravity gravity and weight and the component of this force will remain same only the direction of frictional force will change because now we are moving the body in the upward direction so frictional force will come in direction opposite to the direction of motion

so in this case the applied force f will be equal to $mg \sin 30^\circ$ degree which is the component of this force along this plane in downward direction plus frictional force f and we know the value of frictional force that is equal to $\mu mg \cos 30^\circ$ we know it from the previous uh problem of the part a and we can write this in this form $mg \sin 30^\circ$ degree plus $\mu \cos 30^\circ$ degree and now again putting the value of m g and μ we can write it in this form 2 into 9.8 in bracket 1 by 2 plus $\sqrt{3}$ by $\sqrt{2}$ multiplied by $\sqrt{3}$ by $\sqrt{2}$ and this comes out to be final value comes

out to be 13×30.58 newton

so this is the value of the force that we have to apply on this body

so that it can move in the upward direction

so this is our final answer of this part of the problem after this let's move to the another problem our next problem is in the figure the blocks a b and c have masses 3 kg 4 kg and 8 kg respectively the coefficient of sliding friction between any two surfaces is 0.25 a is held at rest by a massless rigid rod fixed to the wall while b and c are connected by a light flexible chord passing around a fixed frictionless pulley find the force f necessary to drag c along the horizontal surface to the left at a constant speed assume that the arrangement shown in the figure that is b on c and a on b is maintained throughout

so if we try to understand this problem from this figure that is given here then we can see clearly that there are three bodies a b and c their masses are given and they are stacked over each other this body a that is on the top is fixed or hold here by a rigid rod which is connected to this wall here b and c are tied with a string and this is going over a pulley this is a frictionless or smooth pulley and here we are applying a force f coefficient of sliding frictions between any two surfaces means between c and this bottom surface between b and c surface and between a and b surface are given and this is 0.25 for all these cases or between any two surfaces so we are applying here the force f in this direction and we have to find the value of this force

so that c can be dragged in this direction towards the left side at a constant speed

so we can see here first we can write the the values that that are already given in the problem masses of all three bodies are given here 3 kg 4 kg and 8 kg are the masses of body a b and c respectively coefficient of kinetic friction is 0.25 for any two surfaces further we can see that the frictional forces that are acting between these different surfaces can be calculated using these relations like the frictional force between a and b will be equal to $\mu \times m_a \times g$ m_a is the mass of this body that is on the top frictional force between b and c that is between these two will be f_{bc} which will be equal to $\mu \times (m_a + m_b) \times g$ and frictional force between c and the ground surface that is here will be f_{cs} which will be equal to $\mu \times (m_a + m_b + m_c) \times g$ let's say these are our relation 1 2 and 3.

now we see as defined in the problem we are applying a force f on this body that is c and we are trying to drag it in the left direction

so to know the amount of this force let's first identify all the forces acting on the b and the body c

so or if we pull the the c or drag the c in the left side and the c is connected with the b with this string

so this string there will be a tension in this string and it will try to drag the b in right direction

so we can define it like this this is the tension that is on the right direction acting in the right direction on the body b and there will be two frictional forces f_{ab} and f_{bc} because this body b is in contact with the body a that is on the upper side and body c that is in the bottom side

so it is in contact with the the two surfaces of body a and body b and we can say this t will be equal to $f_{ab} + f_{bc}$ further for this part that is the lower body c and here we are applying this force f in this direction so correspondingly the frictional forces again here will be two frictional forces because one because of the surface friction b and c and one will be

because of the friction between the c and the the bottom surface that is $f_c s$ and this t is because of the the string connected there

so tension in the string

so we can say here from this this diagram that f will be equal to t plus f_{bc} plus f_{cs} say this is our relation 5 this is our relation 4 putting the value of this t from relation 4 into this 5 we can rewrite it in this form f is equal to $f_a b$ plus $2 f_b c$ plus $f_c s$ now putting the values of $f_a b$ $f_b c$ and $f_c s$ from our earlier relations of 1 2 and 3 we can rewrite this value of capital f in terms of μ and the masses of the body and g like this μ times in bracket $4 m_a$ plus $3 m_b$ plus m_c into g

so putting the values of the given values of all the masses and value of g that is 9.8 and coefficient of sliding picture that is 0.25 here we can put all these values in this in this relation that comes out to be like this and after solving this simple relation we will get f is equal to 78.4 newton so this is the value of the force that we have to apply here on this body c so that it can move with a constant speed in direction in this direction or towards the left direction

so this is our final answer our next problem is an insect crawls up a hemispherical surface very slowly as shown in the figure the coefficient of friction between the insect and the surface is one by three if the line joining the center of the hemispherical surface to the insect makes an angle alpha with the vertical what will be the maximum possible value of alpha so let's first try to understand this problem with the figure as given in this problem

so here is the hemispherical surface and there is a one insect as shown in the figure it is trying to climb up its crawling up

so at any given position or any instant of time there will be multiple forces will be acting on this insect we can see there will be a force normal to this surface this is a reaction force this is given by n here this is acting in this direction that is perpendicular to this surface and this is along also along the line joining the insect with the center of this hemisphere and it's making an angle alpha with this vertical line there is a one force acting in the downward direction because of the mass and gravity and there will be one component of this force that will act in this direction perpendicular to the surface but opposite to the reaction force and this will make an angle alpha with respect to this force and there will be another component of this force mg that will act in this direction that is a tangential to this surface this is this will be $mg \sin \alpha$ when the instead it

so now let's see when the insect is crawling up then at any instant it's not falling because two forces are acting in opposite directions one is because of the the weight or the gravity this is acting in this direction this is $mg \sin \alpha$ and the force this this is basically trying to pull it down

so because of this force it can fall down but at the same time there is a one force this is due to the friction this will be acting on the opposite direction and it will not let the insect fall down

so if it is not falling it means frictional force is higher than the this component of force that is acting in the downward direction but there will be a certain condition or or one condition when it is slowly slowly moving up so this $mg \sin \alpha$ the value of $mg \sin \alpha$ will increase because you are increasing the value of alpha while the f value of frictional force will be constant

so at some position this $mg \sin \alpha$ will be equal to f for a particular value of alpha that will be the maximum value of alpha above that if you go then value of $mg \sin \alpha$ will be higher comparing to the frictional force

and the insect will start falling down or coming down from its position

so we have to find out the situation when this value of f is equal to $mg \sin \alpha$ or we have to find the value of α at which frictional force and the downward force that is $mg \sin \alpha$ are equal

so here we can see now let's start writing the values of these forces

so we know the value of n that is the reaction force n here will be equal to $mg \cos \alpha$ because there is no movement in this direction

so this is equilibrium state and these forces will be equal and opposite

so n is equal to $mg \cos \alpha$ frictional force we can write f we can represent it by small f and it will be equal to μ times reaction force this is the standard relation and as defined in the condition for the maximum value of α f will also be equal to $mg \sin \alpha$

so this is the maximum value of α up to which the insect can crawl up without falling down

so now from 1, 2 and 3, 1, 2 and 3 from these relations we can simply write it in this form that is $\mu mg \cos \alpha$ is equal to $mg \sin \alpha$ we are just putting these values in these relations and from here we can write μ is equal to $\tan \alpha$ or the value of μ is already given that is $1/3$

so we can write simply $\tan \alpha$ is equal to $1/3$ or in other way we can write it as a $\cot \alpha$ is equal to 3 now depending on the nature of a problem suppose you are asked to provide the specific value of α then you can further solve it and find the value of α that will give you the value $\cot \alpha$ is equal to 3 or if in the multiple choice or single choice type objective questions if this is the answer in this form $\cot \alpha$ is equal to 3 then you can leave your answer up to here

so this is our final answer

so this was the last problem of this session with this we end this session of solving the problems on laws of motion it was my pleasure solving these problems for you thank you for your attention bye