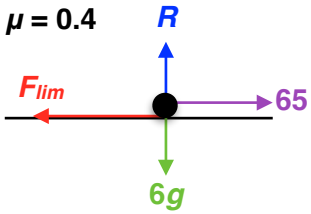
Motion on a Slope

Starter

1. **Horizontal plane**

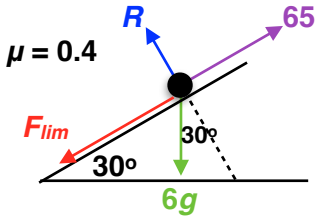
(Review of last lesson)

A mass of 6 kg is pulled along a horizontal plane by a horizontal force of 65 N. The coefficient of friction between the particle and surface is 0.4. Find the acceleration of the particle.



2. **Inclined plane**

What will the acceleration be if the plane is inclined at an angle of 30^o and the force of 65 N acts parallel and up the slope?



Notes

On rough inclined planes, resolving horizontally and vertically does not work so we need to be able to resolve in different directions

Inclined planes — resolve ***parallel*** and ***perpendicular*** to the plane

$R(\perp) \equiv$ **resolving perpendicular to the plane** — only look at forces perpendicular to the plane
$R(//) \equiv$ **resolving parallel to the plane** — only look at forces parallel to the plane

N.B. The normal contact force always acts perpendicular to the plane

Solving friction problems on inclined planes

When doing friction questions, do these three things:

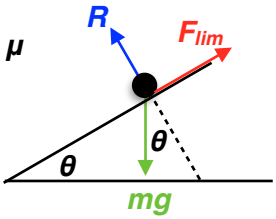
- $R(\perp)$: resolve perpendicular to the plane to find R, the normal contact force.
- $F_{lim} = \mu R$: use $F_{lim} = \mu R$ to find the limiting (maximum) frictional force.
- $R(//)$ or $F = ma(//)$: resolve or use $F = ma$ parallel to the plane

N.B. The difference is just which order you do them in — usually it doesn't matter
Resolve parallel to the plane, $R(//)$, when in ***limiting equilibrium***
Use $F = ma(//)$ when $a \neq 0$

For ***E.g. 1—3***, (a) $R(\perp)$ (b) use $F_{lim} = \mu R$ (c) $R(//)$ or $F = ma(//)$

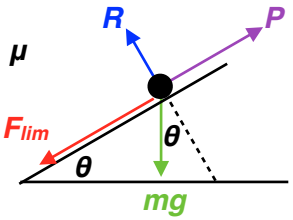
E.g. 1 Accelerating down the plane under its own weight

Mass = m kg, plane inclined at θ, acceleration = a

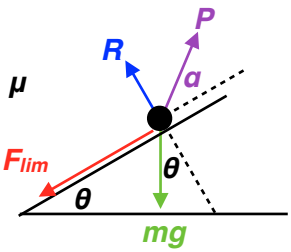


E.g. 2 Accelerating up the plane under the action of force P acting parallel to the plane

Mass = m kg, plane inclined at θ, acceleration = a



E.g. 3 ***Accelerating up the plane under the action of force P acting at an angle of α to the plane***
Mass = m kg, plane inclined at θ, acceleration = a



E.g. 4 A snow-covered hill is at an angle of 13° to the horizontal. A toboggan of weight 75 N is placed on the hill. Given that the coefficient of friction between the toboggan and the hill is 0.15, find whether the toboggan will slide down the hill by itself. If so, calculate the acceleration.

E.g. 5 A box of mass 2 kg is at rest on a rough plane inclined at an angle of θ to the horizontal. A force of 12 N acts up the plane on the box, which is on the point of moving up the slope. Given that $\cos\theta = \frac{4}{5}$, find the coefficient of friction between the box and the plane to 3 s.f.

E.g. 6 A stone of mass 8 kg is at rest on a rough slope inclined at 23° to the horizontal. A force of magnitude 9 N acts on the box at an angle of 10° to the slope. Calculate the coefficient of friction given that the 9 N force is just enough to stop the stone sliding down the slope.

E.g. 7* A box of mass 10 kg lies on a rough plane inclined at an angle of 35° to the horizontal. The coefficient of friction is 0.6. A force of P N acts up and parallel to the plane. Given that the box is in limiting equilibrium, calculate the range of values of P.

Exercise

1. A dustbin of mass 20 kg is on a path which is at an angle of 10° to the horizontal. $F_{lim} = 50$ N.
   (a) Will the bin slide down the path?
   (b) A force parallel to the slope is applied to the bin so that it is on the point of moving up the path. How large is the force?
2. A block of mass 7 kg is at rest on a rough plane inclined at an angle of 45°. A force of 30 N acts up the plane on the block, which is on the point of moving down the slope. Find the coefficient of friction between the block and the plane to 2 decimal places.
3. A particle of weight 8 N is resting in rough contact with a plane inclined at an angle α to the horizontal where tan α = $\frac{3}{4}$. The coefficient of friction between the particle and the plane is μ. A horizontal force P newtons is applied to the particle. When $P = 16$ the particle is on the point of slipping up the plane.
   (a) Find μ.
   (b) Find the value of P such that the particle is just prevented from slipping down the plane.
4. A warehouse porter is trying to push a trolley, of mass 24 kg, up a plane inclined at an angle of α to the horizontal where $\tan\alpha = \frac{5}{12}$. He finds that the trolley is just on the point of moving when the horizontal force he is exerting on the handles reaches 200 N. Using $g = 10$, find the value of the coefficient of friction between the trolley and the plane.
5. A rock weighing 5000 N is being pulled up a rough inclined plane which is at an angle of 10° to the horizontal. The coefficient of friction is 0.1. The rock is accelerating up the plane at a rate of 0.35 m/s². Find the tension in the rope pulling the rock.