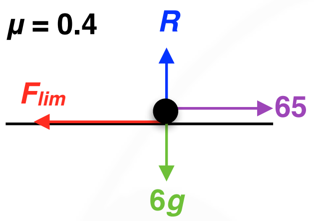
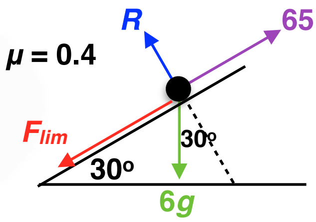
Motion on a Slope

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

Horizontal planes — resolve ***horizontally*** and ***vertically***
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

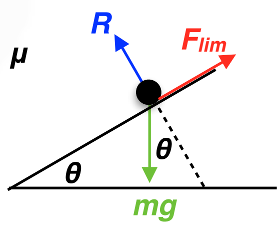
Solving friction problems on inclined planes

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 $a \neq 0$

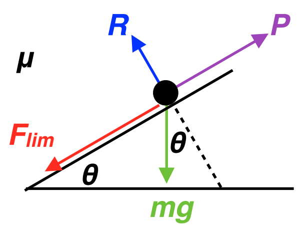
E.g. 1 Accelerating down the plane under its own weight
Mass = m kg, plane inclined at θ, acceleration = a



Working: Friction is resisting motion down the slope.

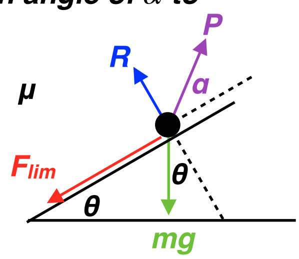
$R(\perp)$: $R = mg\cos\theta$
$F_{lim} = \mu R$: $F_{lim} = \mu mg\cos\theta$
$F = ma(//)$: $mg\sin\theta - F_{lim} = ma$

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



N.B. Make sure you draw a diagram for each question.

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.

Working:

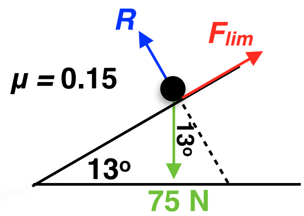
$R(\perp)$: $R = 75\cos 13$

$F_{lim} = \mu R$: $F_{lim} = 0.15 \times 75\cos 13 = 11.25\cos 13$

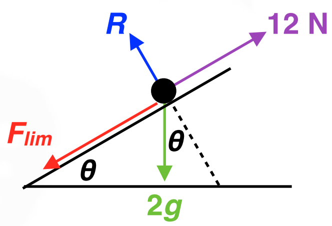
$F = ma(//)$: $75\sin 13 - F_{lim} = \frac{75}{g}a$

$$75\sin 13 - 11.25\cos 13 = \frac{75}{g}a$$

Since $75\sin 13 > 11.25\cos 13$, the toboggan will slide down the hill.
The acceleration is 0.772 m/s² (3 s.f.)



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.

Hint The box could be just about to move up the slope or down the slope.
If it is ***about to move up*** the slope, ***friction is acting down the slope***.
If it is ***about to move down*** the slope, ***friction is acting up the slope***.

Video: Motion on rough inclined plane
Video: Motion on rough inclined plane example

Motion on rough inclined plane EQ

Solutions to Starter and E.g.s

Exercise
p488 21C Qu 3-8

Summary
Inclined planes — resolve ***parallel*** and ***perpendicular*** to the plane
N.B. The normal contact force always acts perpendicular to the plane

Solving friction problems on inclined planes

- $R(\perp)$: resolve perpendicular to the plane to find R, the normal contact force.
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