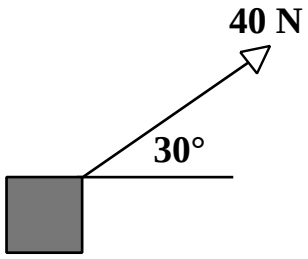
Lesson 2

A-Level Applied Mathematics
Mechanics : Dynamics II : Year 2

2.1 Resolving Forces

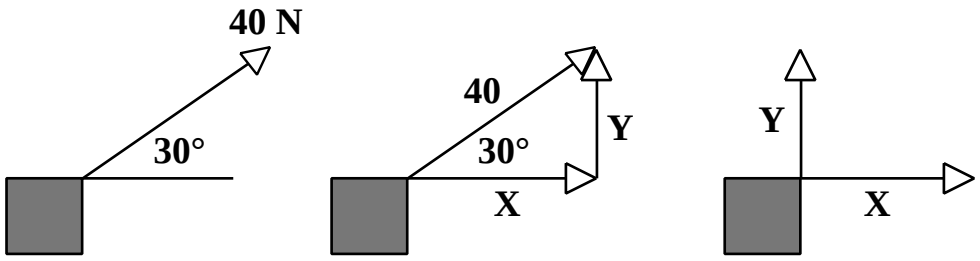
A Motivating Example

At a railway station a man is dragging an 8 kg suitcase along rough ground by its strap.
He pulls with a force of 40 N at an angle of 30° to the horizontal, as shown.
Find the acceleration of the case, given that $\mu = 0.3$.



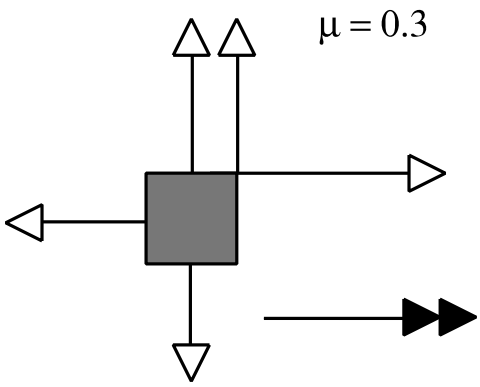
The first step in answering this question is to ***resolve*** the 40 N force.
This means to replace the 40 N force with two new forces, X and Y.
The suitcase "***cannot tell the difference***" between the two situations.
With the 40 N force gone, X and Y will cause the suitcase to move in the same way.

- ◇ In particular it will have the same acceleration as before.
- ◇ Any friction force will be the same.
- ◇ A tiny ant, between the suitcase and the ground would feel the same weight of suitcase pressing down.



Resolving the 40 N force into X and Y is a GCSE trigonometry problem.

Now, we can redraw the system showing all forces acting on the suitcase.

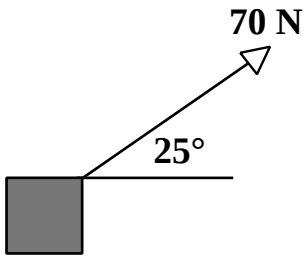


And use our previously developed techniques to find, as asked, the acceleration.

2.2 Exercise

Question 1

An 11 kg box is dragged along rough ground by a rope inclined at 25° to the horizontal as shown below. The tension in the rope is 70 N and μ =0.55.



(a) The 70 N force is to be resolved into its component parts.

(i) Which part acts in the *x*-axis direction ?

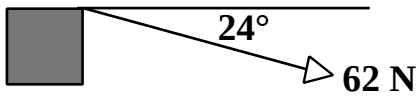
(ii) Which part acts in the *y*-axis direction ?

(b) Redraw the system showing all forces acting on the suitcase and with the 70 N force replaced with your part **(a)** answers.

(c) Find the acceleration of the box.

Question 2

An 7 kg box is dragged along rough ground by a rope at 24° to the horizontal as shown below. The tension in the rope is 62 N and μ =0.4.



(a) The 62 N force is to be resolved into its component parts.

(i) What part acts in the *x*-axis direction ?

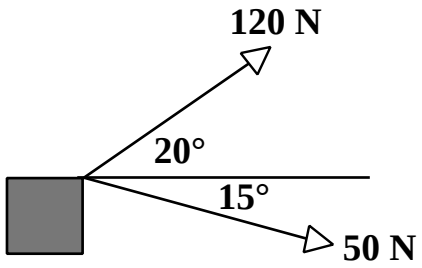
(ii) What part acts in the (negative) *y*-axis direction ?

(b) Redraw the system showing all forces acting on the suitcase and with the 62 N force replaced with your part **(a)** answers.

(c) Find the acceleration of the box.

Question 3

An 35 kg sledge is dragged along rough ground by two ropes.
One is attached to a man, who pulls with a force of 120 N at 20° above the horizontal.
The other is attached to a dog pulling with 50 N inclined at 15° below the horizontal.
The coefficient of friction, μ, is 0.26.



(a) The 120 N force is to be resolved into its component parts.

(i) What part acts in the *x*-axis direction ?

(ii) What part acts in the *y*-axis direction ?

(b) The 50 N force is to be resolved into its component parts.

(i) What part acts in the *x*-axis direction ?

(ii) What part acts in the (negative) *y*-axis direction ?

(c) Redraw the system showing all forces acting on the sledge and with the 120 N force replaced with your part **(a)** answers and the 50 N force replaced with your part (b) answers.
Make your diagram large so that you can clearly see what's going on.

(d) Find the acceleration of the sledge.

Question 4

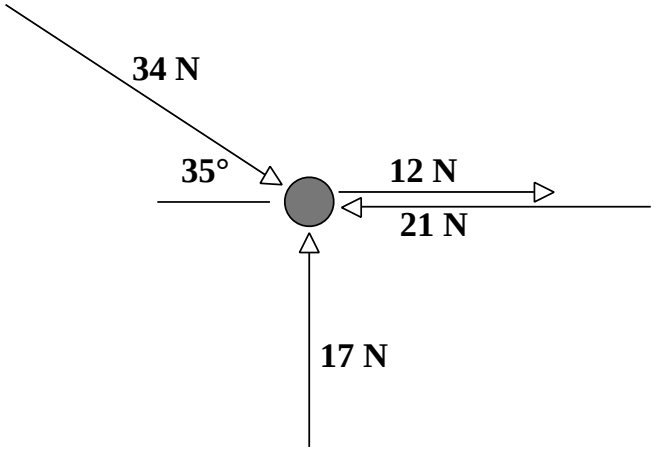
A particle of mass 4 kg is being pulled across a rough horizontal plane by a string inclined at an angle of 20° above the horizontal. When the tension in the string is 25 N the particle accelerates at 4 ms^{-2}.

Find the coefficient of friction between the particle and the plane.

HINT : Start be resolving the 25 N force at 20° into its component parts.
Then draw a large diagram with all forces shown.

Question 5

Four forces act on a particle as shown below.



(a) The 34 N force is to be resolved into its component parts.

(i) What part acts in the *x*-axis direction ?

(ii) What part acts in the (negative) *y*-axis direction ?

(b) With the 34 N force replaced with its component parts,

(i) What is the unbalanced force in the *x*-axis direction ?

(ii) What is the unbalanced force in the *y*-axis direction ?

(c) Combine your **(b) (i)** and **(b) (ii)** answers using the theorem of Pythagoras to get the magnitude of the single resultant force that could replace all four of the original forces and which would cause the particle to move in the same way.

(d) Relative to the positive *x*-axis in what direction does the resultant force act.