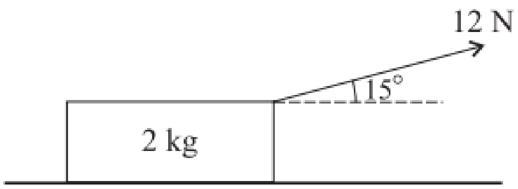
Forces and Motion (Statics and Dynamics in 2d with Friction) (From OCR 4728)

Q1, (Jan 2006, Q4)



A block of mass 2 kg is at rest on a rough horizontal plane, acted on by a force of magnitude 12 N at an angle of 15° upwards from the horizontal (see diagram).

(i) Find the frictional component of the contact force exerted on the block by the plane. [2]

(ii) Show that the normal component of the contact force exerted on the block by the plane has magnitude 16.5 N, correct to 3 significant figures. [2]

It is given that the block is on the point of sliding.

(iii) Find the coefficient of friction between the block and the plane. [2]

The force of magnitude 12 N is now replaced by a horizontal force of magnitude 20 N. The block starts to move.

(iv) Find the acceleration of the block. [5]

Q2, (Jun 2006, Q7)

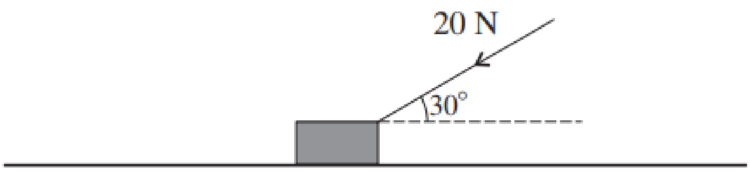
A particle of mass 0.1 kg is at rest at a point A on a rough plane inclined at 15° to the horizontal. The particle is given an initial velocity of 6 m s^{-1} and starts to move up a line of greatest slope of the plane. The particle comes to instantaneous rest after 1.5 s.

(i) Find the coefficient of friction between the particle and the plane. [7]

(ii) Show that, after coming to instantaneous rest, the particle moves down the plane. [2]

(iii) Find the speed with which the particle passes through A during its downward motion. [6]

Q3, (Jan 2009, Q4)



A block of mass 3 kg is placed on a horizontal surface. A force of magnitude 20 N acts downwards on the block at an angle of 30° to the horizontal (see diagram).

(i) Given that the surface is smooth, calculate the acceleration of the block. **[3]**

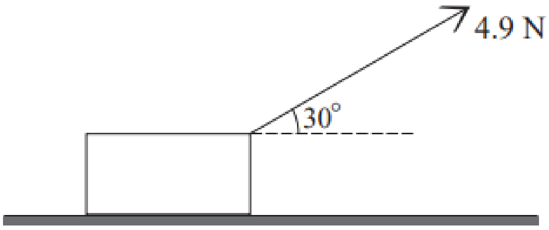
(ii) Given instead that the block is in limiting equilibrium, calculate the coefficient of friction between the block and the surface. **[5]**

Q4, (Jan 2008, Q6)

A block of weight 14.7 N is at rest on a horizontal floor. A force of magnitude 4.9 N is applied to the block.

(i) The block is in limiting equilibrium when the 4.9 N force is applied horizontally. Show that the coefficient of friction is $\frac{1}{3}$. [2]

(ii)



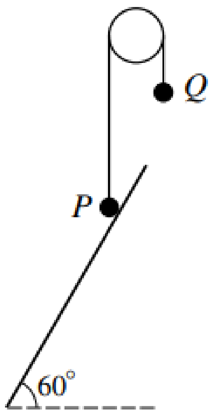
When the force of 4.9 N is applied at an angle of 30° above the horizontal, as shown in the diagram, the block moves across the floor. Calculate

(a) the vertical component of the contact force between the floor and the block, and the magnitude of the frictional force, [5]

(b) the acceleration of the block. [5]

(iii) Calculate the magnitude of the frictional force acting on the block when the 4.9 N force acts at an angle of 30° to the upward vertical, justifying your answer fully. [4]

Q5, (Jan 2010, Q4)



Particles P and Q, of masses 0.4 kg and 0.3 kg respectively, are attached to the ends of a light inextensible string. The string passes over a smooth fixed pulley and the sections of the string not in contact with the pulley are vertical. P rests in limiting equilibrium on a plane inclined at 60° to the horizontal (see diagram).

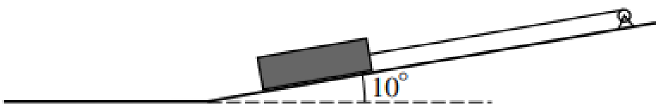
(i) (a) Calculate the components, parallel and perpendicular to the plane, of the contact force exerted by the plane on P. **[4]**

(b) Find the coefficient of friction between P and the plane. **[2]**

P is held stationary and a particle of mass 0.2 kg is attached to Q. With the string taut, P is released from rest.

(ii) Calculate the tension in the string and the acceleration of the particles. **[4]**

Q6, (Jan 2010, Q7)



A winch drags a log of mass 600 kg up a slope inclined at 10° to the horizontal by means of an inextensible cable of negligible mass parallel to the slope (see diagram). The coefficient of friction between the log and the slope is 0.15, and the log is initially at rest at the foot of the slope. The acceleration of the log is 0.11 m s^{-2}.

(i) Calculate the tension in the cable. **[5]**

The cable suddenly breaks after dragging the log a distance of 10 m.

(ii) (a) Show that the deceleration of the log while continuing to move up the slope is 3.15 m s^{-2}, correct to 3 significant figures. **[2]**

(b) Calculate the time taken, after the cable breaks, for the log to return to its original position at the foot of the slope. **[9]**

Q7, (Jan 2012, Q6i,ii)

A particle P of mass 0.3 kg is projected upwards along a line of greatest slope from the foot of a plane inclined at 30° to the horizontal. The initial speed of P is 4 m s^{-1} and the coefficient of friction is 0.15. The particle P comes to instantaneous rest before it reaches the top of the plane.

(i) Calculate the distance P moves up the plane. **[6]**

(ii) Find the time taken by P to return from its highest position on the plane to the foot of the plane. **[4]**

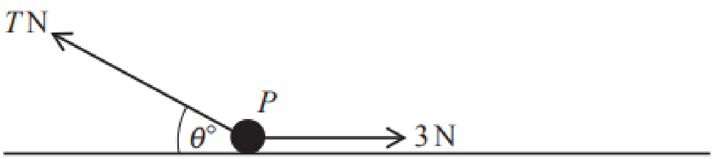
Q8, (Jun 2014, Q6)

A particle P of weight 8 N rests on a horizontal surface. A horizontal force of magnitude 3 N acts on P, and P is in limiting equilibrium.

(i) Calculate the coefficient of friction between P and the surface. **[2]**

(ii) Find the magnitude and direction of the contact force exerted by the surface on P. **[4]**

(iii)

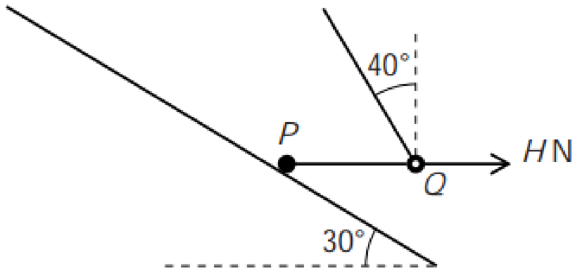


The initial 3 N force continues to act on P in its original direction. An additional force of magnitude T N, acting in the same vertical plane as the 3 N force, is now applied to P at an angle of θ° above the horizontal (see diagram). P is again in limiting equilibrium.

(a) Given that $\theta = 0$, find T. **[2]**

(b) Given instead that $\theta = 30$, calculate T. **[6]**

Q9, (Jun 2012, Q6)



A particle P lies on a slope inclined at 30° to the horizontal. P is attached to one end of a taut light inextensible string which passes through a small smooth ring Q of mass m kg. The portion PQ of the string is horizontal and the other portion of the string is inclined at 40° to the vertical. A horizontal force of magnitude H N, acting away from P, is applied to Q (see diagram). The tension in the string is 6.4 N, and the string is in the vertical plane containing the line of greatest slope on which P lies. Both P and Q are in equilibrium.

(i) Calculate m. **[2]**

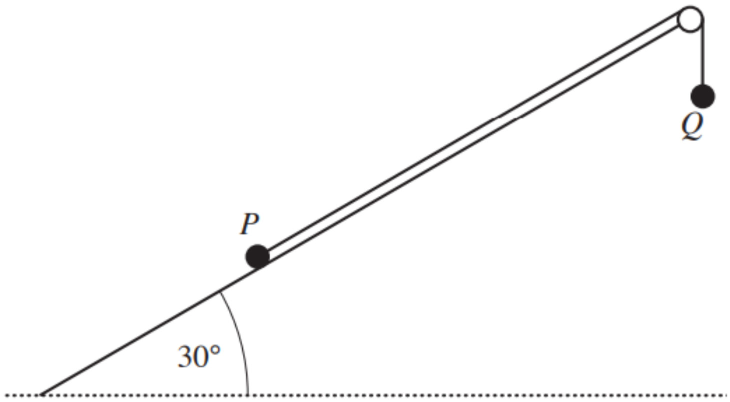
(ii) Calculate H. **[2]**

(iii) Given that the weight of P is 32 N, and that P is in limiting equilibrium, show that the coefficient of friction between P and the slope is 0.879, correct to 3 significant figures. **[6]**

Q and the string are now removed.

(iv) Determine whether P remains in equilibrium. **[3]**

Q10, (Jun 2016, Q6)



Two particles P and Q are attached to opposite ends of a light inextensible string which passes over a small smooth pulley at the top of a rough plane inclined at 30° to the horizontal. P has mass 0.2 kg and is held at rest on the plane. Q has mass 0.2 kg and hangs freely. The string is taut (see diagram). The coefficient of friction between P and the plane is 0.4. The particle P is released.

(i) State the tension in the string before P is released, and find the tension in the string after P is released. **[6]**

Q strikes the floor and remains at rest. P continues to move up the plane for a further distance of 0.8 m before it comes to rest. P does not reach the pulley.

(ii) Find the speed of the particles immediately before Q strikes the floor. **[5]**

(iii) Calculate the magnitude of the contact force exerted on P by the plane while P is in motion. **[3]**