Edexcel GCE

Core Mathematics M1

Dynamics (Planes)

Advice to Candidates

You must ensure that your answers to parts of questions are clearly labelled.
You must show sufficient working to make your methods clear to the Examiner. Answers without working may gain no credit.
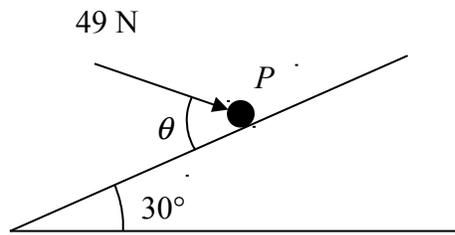
1. A small brick of mass 0.5 kg is placed on a rough plane which is inclined to the horizontal at an angle θ, where $\tan \theta = \frac{4}{3}$, and released from rest. The coefficient of friction between the brick and the plane is $\frac{1}{3}$.

Find the acceleration of the brick.

(9)

2.

Figure 1

49 N

P

θ

30°

A particle P of mass 6 kg lies on the surface of a smooth plane. The plane is inclined at an angle of 30° to the horizontal. The particle is held in equilibrium by a force of magnitude 49 N, acting at an angle θ to the plane, as shown in Figure 1. The force acts in a vertical plane through a line of greatest slope of the plane.
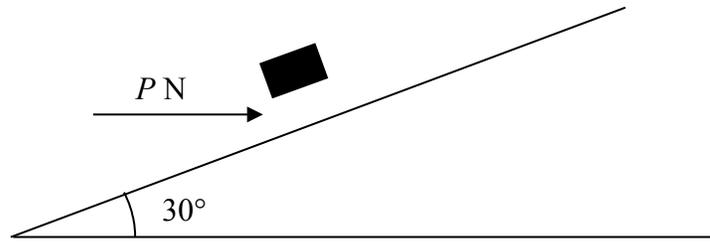
(a) Show that $\cos \theta = \dfrac{3}{5}$.

(3)

(b) Find the normal reaction between P and the plane.

(4)

The direction of the force of magnitude 49 N is now changed. It is now applied horizontally to P so that P moves up the plane. The force again acts in a vertical plane through a line of greatest slope of the plane.

(c) Find the initial acceleration of P.

(4)

3.

Figure 2

A parcel of weight 10 N lies on a rough plane inclined at an angle of 30° to the horizontal. A horizontal force of magnitude P newtons acts on the parcel, as shown in Figure 2. The parcel is in equilibrium and on the point of slipping up the plane. The normal reaction of the plane on the parcel is 18 N. The coefficient of friction between the parcel and the plane is μ. Find
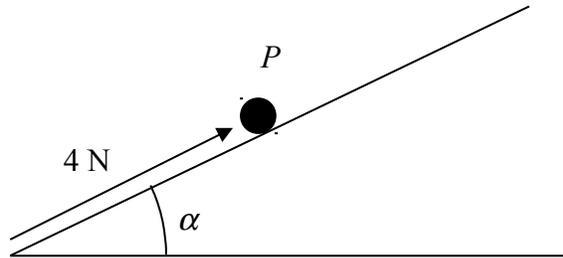
(*a*) the value of P,

(4)

(*b*) the value of μ.

(5)

The horizontal force is removed.

(*c*) Determine whether or not the parcel moves.

(5)

4.

Figure 2

A particle P of mass 0.5 kg is on a rough plane inclined at an angle α to the horizontal, where tan $\alpha = \frac{3}{4}$. The particle is held at rest on the plane by the action of a force of magnitude 4 N acting up the plane in a direction parallel to a line of greatest slope of the plane, as shown in Figure 2. The particle is on the point of slipping up the plane.

(*a*) Find the coefficient of friction between P and the plane.

(7)

The force of magnitude 4 N is removed.

(*b*) Find the acceleration of P down the plane.

(4)

5.

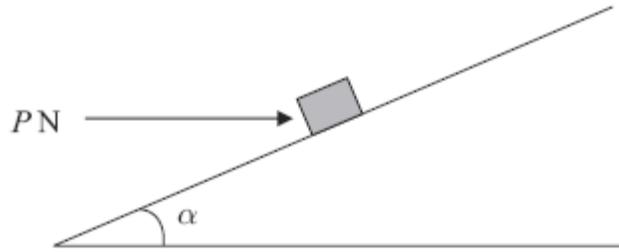**Figure 2**

A small package of mass 1.1 kg is held in equilibrium on a rough plane by a horizontal force. The plane is inclined at an angle α to the horizontal, where $\tan \alpha = \frac{3}{4}$. The force acts in a vertical plane containing a line of greatest slope of the plane and has magnitude P newtons, as shown in Figure 2.

The coefficient of friction between the package and the plane is 0.5 and the package is modelled as a particle. The package is in equilibrium and on the point of slipping down the plane.

(*a*) Draw, on Figure 2, all the forces acting on the package, showing their directions clearly.

(2)

(*b*) (i) Find the magnitude of the normal reaction between the package and the plane.

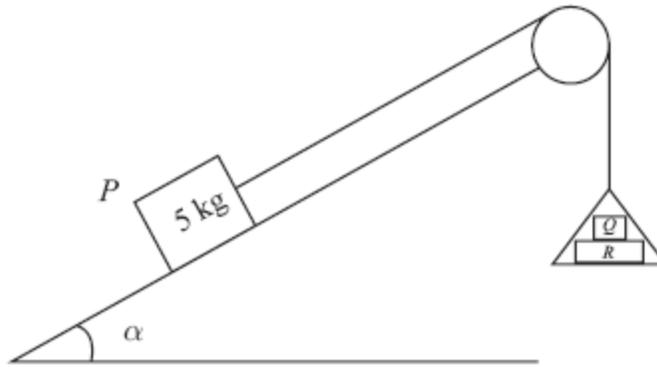(ii) Find the value of P.

(11)

6.

Figure 3

One end of a light inextensible string is attached to a block P of mass 5 kg. The block P is held at rest on a smooth fixed plane which is inclined to the horizontal at an angle α, where $\sin \alpha = \frac{3}{5}$.

The string lies along a line of greatest slope of the plane and passes over a smooth light pulley which is fixed at the top of the plane. The other end of the string is attached to a light scale pan which carries two blocks Q and R, with block Q on top of block R, as shown in Figure 3. The mass of block Q is 5 kg and the mass of block R is 10 kg. The scale pan hangs at rest and the system is released from rest. By modelling the blocks as particles, ignoring air resistance and assuming the motion is uninterrupted, find

(*a*) (i)   the acceleration of the scale pan,

   (ii) the tension in the string,

(8)

(*b*) the magnitude of the force exerted on block Q by block R,

(3)

(*c*) the magnitude of the force exerted on the pulley by the string.

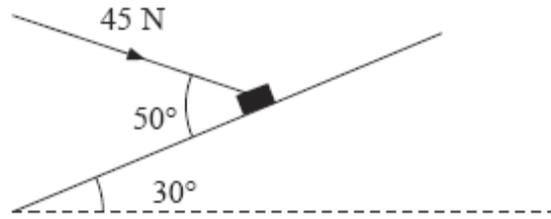**(5)**

7.

45 N

50°

30°

Figure 3

A package of mass 4 kg lies on a rough plane inclined at 30° to the horizontal. The package is held in equilibrium by a force of magnitude 45 N acting at an angle of 50° to the plane, as shown in Figure 3. The force is acting in a vertical plane through a line of greatest slope of the plane. The package is in equilibrium on the point of moving up the plane. The package is modelled as a particle. Find

(*a*) the magnitude of the normal reaction of the plane on the package,

(5)

(*b*) the coefficient of friction between the plane and the package.

(6)

8.

Figure 3

A (3m)   (rough) B (m)

(smooth)

30°   30°
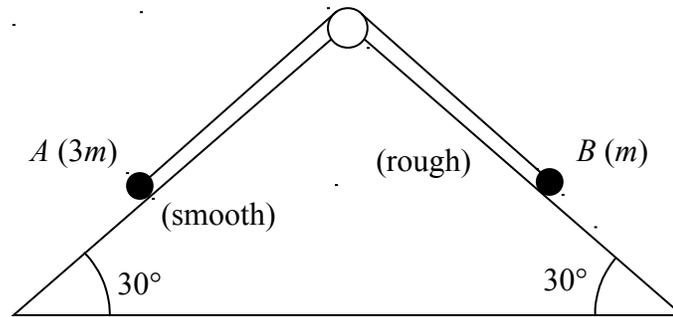
A fixed wedge has two plane faces, each inclined at 30° to the horizontal. Two particles A and B, of mass 3m and m respectively, are attached to the ends of a light inextensible string. Each particle moves on one of the plane faces of the wedge. The string passes over a smooth light pulley fixed at the top of the wedge. The face on which A moves is smooth. The face on which B moves is rough. The coefficient of friction between B and this face is μ. Particle A is held at rest with the string taut. The string lies in the same vertical plane as lines of greatest slope on each plane face of the wedge, as shown in Figure 3.

The particles are released from rest and start to move. Particle A moves downwards and particle B moves upwards. The accelerations of A and B each have magnitude $\frac{1}{10} g$.

(*a*) By considering the motion of A, find, in terms of m and g, the tension in the string.

(3)

(*b*) By considering the motion of B, find the value of μ.

(8)

(*c*) Find the resultant force exerted by the string on the pulley, giving its magnitude and direction.

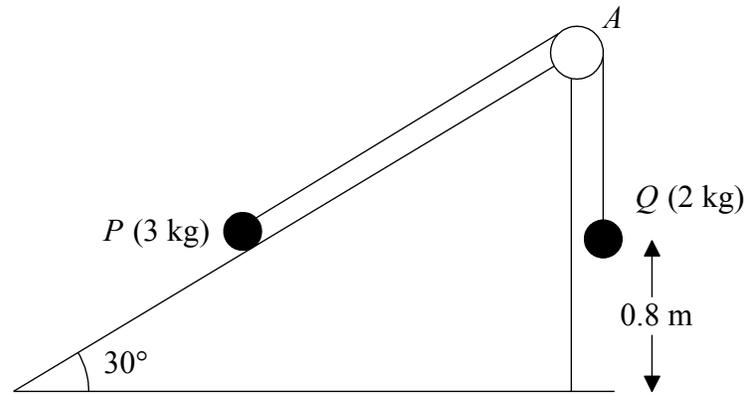**(3)**

9.

Figure 4

Figure 4 shows two particles P and Q, of mass 3 kg and 2 kg respectively, connected by a light inextensible string. Initially P is held at rest on a smooth fixed plane inclined at 30° to the horizontal. The string passes over a small smooth light pulley A fixed at the top of the plane. The part of the string from P to A is parallel to a line of greatest slope of the plane. The particle Q hangs freely below A. The system is released from rest with the string taut.

(*a*) Write down an equation of motion for P and an equation of motion for Q.

(4)

(*b*) Hence show that the acceleration of Q is 0.98 m s^{-2}.

(2)

(*c*) Find the tension in the string.

(2)

(*d*) State where in your calculations you have used the information that the string is inextensible.

(1)

On release, Q is at a height of 0.8 m above the ground. When Q reaches the ground, it is brought to rest immediately by the impact with the ground and does not rebound. The initial distance of P from A is such that in the subsequent motion P does not reach A. Find

(*e*) the speed of Q as it reaches the ground,

(2)

(*f*) the time between the instant when Q reaches the ground and then instant when the string becomes taut again.

(5)