

**1.** A particle *P* moves with constant acceleration (2**i** − 3**j**) m s−2

At time *t* = 0, *P* is moving with velocity 4**i** m s−1

(*a*)Find the velocity of *P* at time *t* = 2 seconds.

**(2)**

At time *t* = 0, the position vector of *P* relative to a fixed origin *O* is (**i** + **j**) m.

(*b*)Find the position vector of *P* relative to *O* at time *t* = 3 seconds.

**(2)**

**(Total for Question 1 is 4 marks)**

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**2.**



A small stone *A* of mass 3*m* is attached to one end of a string.

A small stone *B* of mass *m* is attached to the other end of the string.

Initially *A* is held at rest on a fixed rough plane.

The plane is inclined to the horizontal at an angle *α*, where tan *α* = 

The string passes over a pulley *P* that is fixed at the top of the plane.

The part of the string from *A* to *P* is parallel to a line of greatest slope of the plane.

Stone *B* hangs freely below *P*, as shown in Figure 1.

The coefficient of friction between *A* and the plane is 

Stone *A* is released from rest and begins to move down the plane.

The stones are modelled as particles.

The pulley is modelled as being small and smooth.

The string is modelled as being light and inextensible.

Using the model for the motion of the system before *B* reaches the pulley,

(*a*)write down an equation of motion for *A*

**(2)**

(*b*)show that the acceleration of *A* is 

**(7)**

(*c*)sketch a velocity-time graph for the motion of *B*, from the instant when *A* is released

from rest to the instant just before *B* reaches the pulley, explaining your answer.

**(2)**

In reality, the string is not light.

(*d*)State how this would affect the working in part (*b*).

**(1)**

**(Total for Question 2 is 12 marks)**

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**3.**

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A beam *AB* has mass *m* and length 2*a*.

The beam rests in equilibrium with *A* on rough horizontal ground and with *B* against a

smooth vertical wall.

The beam is inclined to the horizontal at an angle *θ*, as shown in Figure 2.

The coefficient of friction between the beam and the ground is *μ*

The beam is modelled as a uniform rod resting in a vertical plane that is perpendicular

to the wall.

Using the model,

(*a*)show that **

**(5)**

A horizontal force of magnitude *kmg*, where *k* is a constant, is now applied to the beam

at *A*.

This force acts in a direction that is perpendicular to the wall and towards the wall.

Given that and the beam is now in limiting equilibrium,

(*b*)use the model to find the value of *k*.

**(5)**

**(Total for Question 3 is 10 marks)**

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**4.**



A small stone is projected with speed 65 m s−1 from a point *O* at the top of a vertical cliff.

Point *O* is 70 m vertically above the point *N*.

Point *N* is on horizontal ground.

The stone is projected at an angle *α* above the horizontal, where tan *α* = 

The stone hits the ground at the point *A*, as shown in Figure 3.

The stone is modelled as a particle moving freely under gravity.

**The acceleration due to gravity is modelled as having magnitude 10 m s−2**

Using the model,

(*a*)find the time taken for the stone to travel from *O* to *A*,

**(4)**

(*b*)find the speed of the stone at the instant just before it hits the ground at *A*.

**(5)**

One limitation of the model is that it ignores air resistance.

(*c*)State one other limitation of the model that could affect the reliability of

your answers.

**(1)**

**(Total for Question 4 is 10 marks)**

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**5.** At time *t* seconds, a particle *P* has velocity **v** m s−1, where



(*a*)Find the acceleration of *P* at time *t* seconds, where *t* > 0

**(2)**

(*b*)Find the value of *t* at the instant when *P* is moving in the direction of **i** − **j**

**(3)**

At time *t* seconds, where *t* > 0, the position vector of *P*, relative to a fixed origin *O*,

is **r** metres.

When *t* = 1, **r** = −**j**

(*c*)Find an expression for **r** in terms of *t*.

**(3)**

(*d*)Find the exact distance of *P* from *O* at the instant when *P* is moving with

speed 10 m s−1

**(6)**

**(Total for Question 5 is 14 marks)**

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**TOTAL FOR MECHANICS IS 50 MARKS**