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**1.** Two cyclists, *A* and *B*, are cycling along the same straight horizontal track.

The cyclists are modelled as particles and the motion of the cyclists is modelled

as follows:

* At time *t* = 0 , cyclist *A* passes through the point *O* with speed 2 m s–1
* Cyclist *A* is moving in a straight line with constant acceleration 2 m s–2
* At time *t* = 2 seconds, cyclist *B* starts from rest at *O*
* Cyclist *B* moves with constant acceleration 6 m s–2 along the same straight line and

in the same direction as cyclist *A*

* At time *t* = *T* seconds, *B* overtakes *A* at the point *X*

Using the model,

(*a*)sketch, on the **same** axes, for the interval from *t* = 0 to *t* = *T* seconds,

* a velocity-time graph for the motion of *A*
* a velocity-time graph for the motion of *B*

**(2)**

(*b*)explain why the two graphs must cross before time *t* = *T* seconds,

**(1)**

(*c*)find the time when *A* and *B* are moving at the same speed,

**(2)**

(*d*)find the distance *OX*

**(5)**

**(Total for Question 1 is 10 marks)**

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**2.** [*In this question* **i** *and* **j** *are horizontal unit vectors*.]

A particle *P* of mass 0.5 kg is moving on a smooth horizontal plane.

The origin *O* is on the plane.

At time *t* = 0 , *P* passes through *O* moving with velocity (**i** – **j**) m s–1

At time *t* seconds, the resultant horizontal force acting on *P* is

[(3*t* – 1)**i** + 2**j**] N

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

**(5)**

(*b*)Find the distance of *P* from *O* at *t* = 2

**(4)**

**(Total for Question 2 is 9 marks)**

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**3.**



A fixed rough plane is inclined to the horizontal at an angle *α*, where tan *α* = 

A small smooth light pulley *P* is fixed at the top of the plane.

A particle *A* of mass 2*m* and a particle *B* of mass *m* are connected by a rope.

The rope passes over the pulley *P*

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

Particle *B* is held at rest on the rough plane and *A* hangs freely with the rope taut, as

shown in Figure 1.

Particle *B* is released from rest and begins to move up the plane.

(*a*)Find, in terms of *mg*, the magnitude of the normal reaction that the plane exerts

on *B*.

**(2)**

The rope is modelled as being light and inextensible.

As *B* moves up the plane, the tension in the rope has magnitude 

The coefficient of friction between *B* and the plane is *μ*.

Using the model,

(*b*)(i) write down an equation of motion for *A*,

(ii) hence, find in terms of *g*, the magnitude of the acceleration of *A*,

**(3)**

(*c*)find the value of *μ*.

**(5)**

In reality, the rope would not be light.

(*d*)State how this would affect the tension in the rope.

**(1)**

**(Total for Question 3 is 11 marks)**

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**4.** [ *In this question the unit vectors* **i** *and* **j** *are directed horizontally and*

 *vertically upwards respectively*.]



The point *O* is 9.6 m above horizontal ground.

A small ball is projected with velocity (4*U* **i** + *U* **j**) m s–1, where *U* is a positive constant,

from the point *O*

The ball first hits the ground *T* seconds later, at the point *A*

The point *A* is at a horizontal distance of 64 m from *O*, as shown in Figure 2.

In an initial model

* the ball is modelled as a particle moving under gravity
* air resistance is ignored
* the ball has an initial speed of *V* m s–1

Using this model,

(*a*)show that *UT* = 16

**(2)**

(*b*)find the value of *V*

**(6)**

(*c*)State two improvements to the model, other than including air resistance, that would

make the model more realistic.

**(2)**

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

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**5.**



A non-uniform rod *AB* is held in equilibrium in a horizontal position by two light

inextensible strings.

The first string has one end attached to the end *A* of the rod and the other end attached

to a point *C* on a horizontal ceiling.

The second string has one end attached to the end *B* of the rod and the other end

attached to a point *D* on the horizontal ceiling, as shown in Figure 3.

The points *A*, *B*, *C* and *D* all lie in the same vertical plane.

Given that

* the rod *AB* has weight *W* and length *a*
* the centre of mass of the rod is a distance *a* from *A*
* the string *AC* makes an angle *α* with the horizontal, where tan *α* = 
* the string *BD* makes an angle *β* with the horizontal

(*a*)show that the tension in the string *AC* is 

**(3)**

The tension in the string *BD* is *S*

(*b*)Show that *S* sin *β* =

**(2)**

(*c*)Find *S* in terms of *W*

**(5)**

**(Total for Question 5 is 10 marks)**

**TOTAL FOR MECHANICS IS 50 MARKS**