

**Candidates may use any calculator allowed by Pearson regulations.**

**Calculators must not have the facility for symbolic algebra**

**manipulation, differentiation and integration, or have retrievable**

**mathematical formulae stored in them.**

**Instructions**

* Use **black** ink or ball-point pen.
* If pencil is used for diagrams / sketches / graphs it must be dark (HB or B).
* Answer **all** questions and ensure that your answers to parts of questions are clearly labelled.
* Answer the questions in the spaces provided
 *– there may be more space than you need.*
* You should show sufficient working to make your methods clear.

 Answers without working may not gain full credit.

* Answers should be given to three significant figures unless otherwise stated.

**Information**

* A booklet ‘Mathematical Formulae and Statistical Tables’ is provided.
* There are 5 questions in this question paper. The total mark for this paper is 50.
* The marks for **each** question are shown in brackets
 *– use this as a guide as to how much time to spend on each question.*

**Advice**

* Read each question carefully before you start to answer it.
* Try to answer every question.
* Check your answers if you have time at the end.

**Answer ALL questions. Write your answers in the spaces provided.**

1. [*In this question position vectors are given relative to a fixed origin O*]

At time *t* seconds, where *t* ≥ 0, a particle, *P*, moves so that its velocity **v** m s−1
is given by

**v** = 6*t***i** − 5**j**

When *t* = 0, the position vector of *P* is (−20**i** + 20**j**) m.

(*a*) Find the acceleration of *P* when *t* = 4

**(3)**

(*b*) Find the position vector of *P* when *t* = 4

**(3)**

**(Total for Question 1 is 6 marks)**

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

At time *t* = 0, the particle is at the point *A* and is moving with velocity (−**i** + 4**j**) m s−1

At time *t* = *T* seconds, *P* is moving in the direction of vector (3**i** − 4**j**)

(*a*) Find the value of *T*.

**(4)**

At time *t* = 4 seconds, *P* is at the point *B*.

(*b*) Find the distance *AB*.

**(4)**

**(Total for Question 2 is 8 marks)**

**3.**



Two blocks, *A* and *B*, of masses 2*m* and 3*m* respectively, are attached to the ends of a light string.

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

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

The string passes over a small smooth pulley, *P*, 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.

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

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

The blocks are released from rest with the string taut and *A* moves up the plane.

The tension in the string immediately after the blocks are released is *T*.

The blocks are modelled as particles and the string is modelled as being inextensible.

(*a*) Show that *T* = 

**(8)**

After *B* reaches the ground, *A* continues to move up the plane until it comes to rest before reaching *P*.

(*b*) Determine whether *A* will remain at rest, carefully justifying your answer.

**(2)**

(*c*) Suggest two refinements to the model that would make it more realistic.

**(2)**

**(Total for Question 3 is 12 marks)**

**4.**



A ramp, *AB*, of length 8 m and mass 20 kg, rests in equilibrium with the end *A* on rough horizontal ground.

The ramp rests on a smooth solid cylindrical drum which is partly under the ground.

The drum is fixed with its axis at the same horizontal level as *A*.

The point of contact between the ramp and the drum is *C*, where *AC* = 5 m, as shown in
Figure 2.

The ramp is resting in a vertical plane which is perpendicular to the axis of the drum,

at an angle *θ* to the horizontal, where tan*θ* = 

The ramp is modelled as a uniform rod.

(*a*) Explain why the reaction from the drum on the ramp at point *C* acts in a direction
which is perpendicular to the ramp.

**(1)**

(*b*) Find the magnitude of the resultant force acting on the ramp at *A*.

 **(9)**

The ramp is still in equilibrium in the position shown in Figure 2 but the ramp is not now modelled as being uniform.

Given that the centre of mass of the ramp is assumed to be closer to *A* than to *B*,

(*c*) state how this would affect the magnitude of the normal reaction between the ramp
and the drum at *C*.

**(1)**

**(Total for Question 4 is 11 marks)**

**5.**



The points *A* and *B* lie 50 m apart on horizontal ground.

At time *t* = 0 two small balls, *P* and *Q*, are projected in the vertical plane containing *AB*.

Ball *P* is projected from *A* with speed 20 m s−1 at 30° to *AB*.

Ball *Q* is projected from *B* with speed *u* m s−1 at angle *θ*  to *BA*, as shown in Figure 3.

At time *t* = 2 seconds, *P* and *Q* collide.

Until they collide, the balls are modelled as particles moving freely under gravity.

(*a*) Find the velocity of *P* at the instant before it collides with *Q*.

**(6)**

(*b*) Find

 (i) the size of angle *θ*,

 (ii) the value of *u*.

**(6)**

(*c*) State one limitation of the model, other than air resistance, that could affect the
accuracy of your answers.

**(1)**

**(Total for Question 5 is 13 marks)**

**TOTAL FOR MECHANICS IS 50 MARKS**