Write your name here

Surname | Other names

**Pearson Edexcel GCE**

Centre Number | Candidate Number

**A level Further Mathematics**

**Further Mechanics 1**

**Practice Paper 4**

**You must have:**
Mathematical Formulae and Statistical Tables (Pink)

Total Marks

**Instructions**

- Use black ink or ball-point pen.
- If pencil is used for diagrams/sketches/graphs it must be dark (HB or B).
- Fill in the boxes at the top of this page with your name, centre number and candidate number.
- Answer all the 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.
- Inexact answers should be given to three significant figures unless otherwise stated.

**Information**

- A booklet 'Mathematical Formulae and Statistical Tables' is provided.
- There are **7** questions in this question paper. The total mark for this paper is **75**.
- The marks for each question are shown in brackets – use this as a guide as to how much time to spend on each question.
- Calculators must not be used for questions marked with a * sign.

**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.
- If you change your mind about an answer, cross it out and put your new answer and any working underneath.

**1.** A ball of mass 0.5 kg is moving with velocity $12\mathbf{i}$ m s$^{-1}$ when it is struck by a bat. The impulse received by the ball is $(-4\mathbf{i} + 7\mathbf{j})$ N s. By modelling the ball as a particle, find

(a) the speed of the ball immediately after the impact,

**(4)**

(b) the angle, in degrees, between the velocity of the ball immediately after the impact and the vector $\mathbf{i}$,

**(2)**

(c) the kinetic energy gained by the ball as a result of the impact.

**(2)**

**(Total 8 marks)**

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**2.**

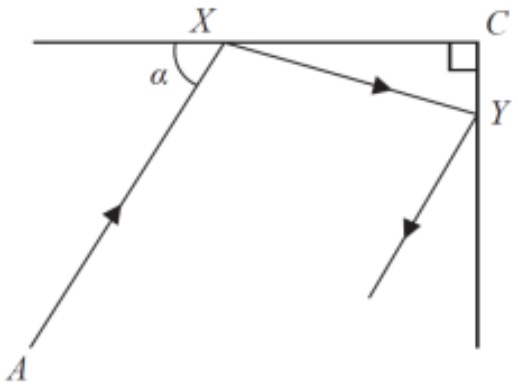


**Figure 1**

A small spherical ball $P$ is at rest at the point $A$ on a smooth horizontal floor. The ball is struck and travels along the floor until it hits a fixed smooth vertical wall at the point $X$. The angle between $AX$ and this wall is $\alpha$, where $\alpha$ is acute. A second fixed smooth vertical wall is perpendicular to the first wall and meets it in a vertical line through the point $C$ on the floor. The ball rebounds from the first wall and hits the second wall at the point $Y$. After $P$ rebounds from the second wall, $P$ is travelling in a direction parallel to $XA$, as shown in Figure 1. The coefficient of restitution between the ball and the first wall is $e$. The coefficient of restitution between the ball and the second wall is $ke$.

Find the value of $k$.

**(Total 9 marks)**

**3.**

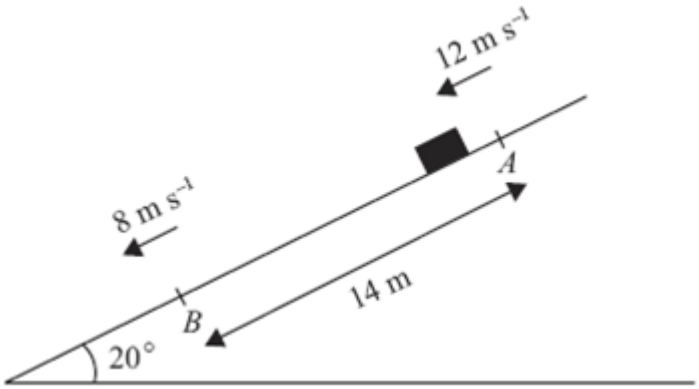


**Figure 2**

A package of mass 3.5 kg is sliding down a ramp. The package is modelled as a particle and the ramp as a rough plane inclined at an angle of 20° to the horizontal. The package slides down a line of greatest slope of the plane from a point $A$ to a point $B$, where $AB = 14$ m. At $A$ the package has speed 12 m s$^{-1}$ and at $B$ the package has speed 8 m s$^{-1}$, as shown in Figure 2.

Find

(a) the total energy lost by the package in travelling from $A$ to $B$,

**(5)**

(b) the coefficient of friction between the package and the ramp.

**(5)**

**(Total 10 marks)**

**4.**

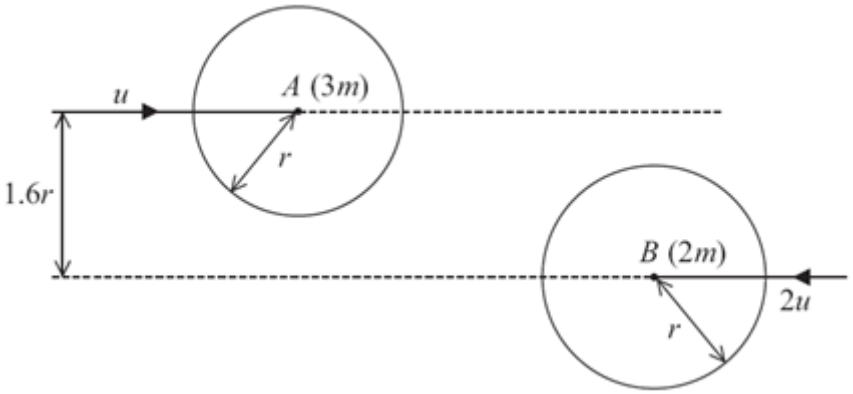


**Figure 3**

Two smooth uniform spheres $A$ and $B$, of equal radius $r$, have masses $3m$ and $2m$ respectively. The spheres are moving on a smooth horizontal plane when they collide. Immediately before the collision they are moving with speeds $u$ and $2u$ respectively. The centres of the spheres are moving towards each other along parallel paths at a distance $1.6r$ apart, as shown in Figure 3.

The coefficient of restitution between the two spheres is $\frac{1}{6}$.

Find, in terms of $m$ and $u$, the magnitude of the impulse received by $B$ in the collision.

**(Total 10 marks)**

**5.** A truck of mass 900 kg is towing a trailer of mass 150 kg up an inclined straight road with constant speed 15 m $s^{-1}$. The trailer is attached to the truck by a light inextensible towbar which is parallel to the road. The road is inclined at an angle $\theta$ to the horizontal, where $\sin\theta = \frac{1}{9}$. The resistance to motion of the truck from non-gravitational forces has constant magnitude 200 N and the resistance to motion of the trailer from non-gravitational forces has constant magnitude 50 N.

(a) Find the rate at which the engine of the truck is working.

**(5)**

When the truck and trailer are moving up the road at 15 m $s^{-1}$ the towbar breaks, and the trailer is no longer attached to the truck. The rate at which the engine of the truck is working is unchanged. The resistance to motion of the truck from non-gravitational forces and the resistance to motion of the trailer from non-gravitational forces are still forces of constant magnitudes 200 N and 50 N respectively.

(b) Find the acceleration of the truck at the instant after the towbar breaks.

**(3)**

(c) Use the work-energy principle to find out how much further up the road the trailer travels before coming to instantaneous rest.

**(4)**

**(Total 12 marks)**

**6.** Two particles $A$ and $B$, of masses $3m$ and $4m$ respectively, lie at rest on a smooth horizontal surface. Particle $B$ lies between $A$ and a smooth vertical wall which is perpendicular to the line joining $A$ and $B$. Particle $B$ is projected with speed $5u$ in a direction perpendicular to the wall and collides with the wall. The coefficient of restitution between $B$ and the wall is $\frac{3}{5}$.

(a) Find the magnitude of the impulse received by $B$ in the collision with the wall.

**(3)**

After the collision with the wall, $B$ rebounds from the wall and collides directly with $A$. The coefficient of restitution between $A$ and $B$ is $e$.

(b) Show that, immediately after they collide, $A$ and $B$ are both moving in the same direction.

**(7)**

The kinetic energy of $B$ immediately after it collides with $A$ is one quarter of the kinetic energy of $B$ immediately before it collides with $A$.

(c) Find the value of $e$.

**(4)**

**(Total 14 marks)**

**7.** A particle $P$ of mass $m$ is attached to one end of a light elastic string of natural length $l$ and modulus of elasticity $3mg$. The other end of the string is attached to a fixed point $O$ on a rough horizontal table. The particle lies at rest at the point $A$ on the table, where $OA = \frac{7}{6}l$. The coefficient of friction between $P$ and the table is $\mu$.

(a) Show that $\mu \geq \frac{1}{2}$.

**(4)**

The particle is now moved along the table to the point $B$, where $OB = \frac{3}{2}l$, and released from rest. Given that $\mu = \frac{1}{2}$, find

(b) the speed of $P$ at the instant when the string becomes slack,

**(5)**

(c) the total distance moved by $P$ before it comes to rest again.

**(3)**

**(Total 12 marks)**

**TOTAL FOR PAPER: 75 MARKS**