Write your name here

| Surname | Other names |
|---|---|
| | |

**Pearson Edexcel GCE**

Centre Number | Candidate Number

# AS and A level Further Mathematics
# Further Mechanics 1

## Practice Paper
## Collisions

**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 8 questions in this question paper. The total mark for this paper is 100.
- 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 particle $P$ of mass $3m$ is moving with speed $2u$ in a straight line on a smooth horizontal plane. The particle $P$ collides directly with a particle $Q$ of mass $4m$ moving on the plane with speed $u$ in the opposite direction to $P$. The coefficient of restitution between $P$ and $Q$ is $e$.

(*a*) Find the speed of $Q$ immediately after the collision.

**(6)**

Given that the direction of motion of $P$ is reversed by the collision,

(*b*) find the range of possible values of $e$.

**(5)**

**(Total 11 marks)**

---

**2.** A particle $P$ of mass $m$ is moving in a straight line on a smooth horizontal surface with speed $4u$. The particle $P$ collides directly with a particle $Q$ of mass $3m$ which is at rest on the surface. The coefficient of restitution between $P$ and $Q$ is $e$. The direction of motion of $P$ is reversed by the collision.

Show that $e > \frac{1}{3}$.

**(Total 8 marks)**

---

**3.** A particle of mass $m$ kg lies on a smooth horizontal surface. Initially the particle is at rest at a point $O$ midway between a pair of fixed parallel vertical walls. The walls are 2 m apart. At time $t = 0$ the particle is projected from $O$ with speed $u$ m s$^{-1}$ in a direction perpendicular to the walls. The coefficient of restitution between the particle and each wall is $\frac{2}{3}$. The magnitude of the impulse on the particle due to the first impact with a wall is $\lambda mu$ N s.

(*a*) Find the value of $\lambda$.

**(3)**

The particle returns to $O$, having bounced off each wall once, at time $t = 3$ seconds.

(*b*) Find the value of $u$.

**(6)**

**(Total 9 marks)**

---

**4.**

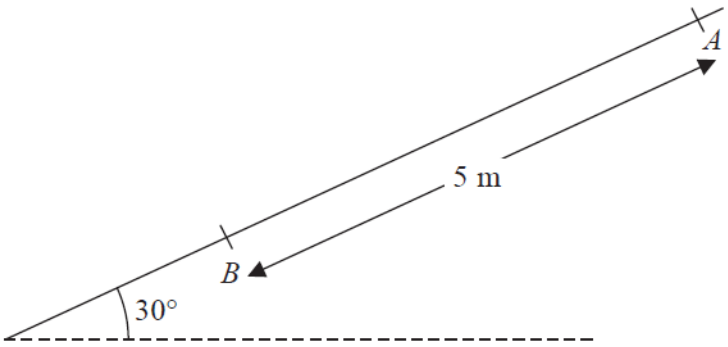


**Figure 1**

A particle $P$ of mass 2 kg is released from rest at a point $A$ on a rough inclined plane and slides down a line of greatest slope. The plane is inclined at 30° to the horizontal. The point $B$ is 5 m from $A$ on the line of greatest slope through $A$, as shown in Figure 1.

(*a*) Find the potential energy lost by $P$ as it moves from $A$ to $B$.

**(2)**

The speed of $P$ as it reaches $B$ is 4 m s$^{-1}$.

(*b*) (i) Use the work-energy principle to find the magnitude of the constant frictional force acting on $P$ as it moves from $A$ to $B$.

(ii) Find the coefficient of friction between $P$ and the plane.

**(7)**

The particle $P$ is now placed at $A$ and projected down the plane towards $B$ with speed 3 m s$^{-1}$. Given that the frictional force remains constant,

(*c*) find the speed of $P$ as it reaches $B$.

**(4)**

**(Total 13 marks)**

**5.** Three identical particles, $A$, $B$ and $C$, lie at rest in a straight line on a smooth horizontal table with $B$ between $A$ and $C$. The mass of each particle is $m$. Particle $A$ is projected towards $B$ with speed $u$ and collides directly with $B$. The coefficient of restitution between each pair of particles is $\frac{2}{3}$.

(*a*) Find, in terms of $u$,

(i) the speed of $A$ after this collision,

(ii) the speed of $B$ after this collision.

**(7)**

(*b*) Show that the kinetic energy lost in this collision is $\frac{5}{36}mu^2$.

**(4)**

After the collision between $A$ and $B$, particle $B$ collides directly with $C$.

(*c*) Find, in terms of $u$, the speed of $C$ immediately after this collision between $B$ and $C$.

**(4)**

**(Total 15 marks)**

---

**6.** Three particles $P$, $Q$ and $R$ lie at rest in a straight line on a smooth horizontal table with $Q$ between $P$ and $R$. The particles $P$, $Q$ and $R$ have masses $2m$, $3m$ and $4m$ respectively. Particle $P$ is projected towards $Q$ with speed $u$ and collides directly with it. The coefficient of restitution between each pair of particles is $e$.

(*a*) Show that the speed of $Q$ immediately after the collision with $P$ is $\frac{2}{5}(1 + e)u$.

**(6)**

After the collision between $P$ and $Q$ there is a direct collision between $Q$ and $R$.

Given that $e = \frac{3}{4}$, find

(*b*) (i) the speed of $Q$ after this collision,

(ii) the speed of $R$ after this collision.

**(6)**

Immediately after the collision between $Q$ and $R$, the rate of increase of the distance between $P$ and $R$ is $V$.

(*c*) Find $V$ in terms of $u$.

**(3)**

**(Total 15 marks)**

**7.** A particle $A$ of mass $m$ is moving with speed $u$ on a smooth horizontal floor when it collides directly with another particle $B$, of mass $3m$, which is at rest on the floor. The coefficient of restitution between the particles is $e$. The direction of motion of $A$ is reversed by the collision.

($a$) Find, in terms of $e$ and $u$,

(i) the speed of $A$ immediately after the collision,

(ii) the speed of $B$ immediately after the collision.

**(7)**

After being struck by $A$ the particle $B$ collides directly with another particle $C$, of mass $4m$, which is at rest on the floor. The coefficient of restitution between $B$ and $C$ is $2e$. Given that the direction of motion of $B$ is reversed by this collision,

($b$) find the range of possible values of $e$,

**(6)**

($c$) determine whether there will be a second collision between $A$ and $B$.

**(3)**

**(Total 16 marks)**

---

**8.** Three identical particles $P$, $Q$ and $R$, each of mass $m$, lie in a straight line on a smooth horizontal plane with $Q$ between $P$ and $R$. Particles $P$ and $Q$ are projected directly towards each other with speeds $4u$ and $2u$ respectively, and at the same time particle $R$ is projected along the line away from $Q$ with speed $3u$. The coefficient of restitution between each pair of particles is $e$. After the collision between $P$ and $Q$ there is a collision between $Q$ and $R$.

($a$) Show that $e > \frac{2}{3}$.

**(7)**

It is given that $e = \frac{3}{4}$.

($b$) Show that there will not be a further collision between $P$ and $Q$.

**(6)**

**(Total 13 marks)**

---

**TOTAL FOR PAPER: 100 MARKS**