Oblique impact with a smooth plane

Further Mechanics 1 | Edexcel 9FM0 | 12 questions, 90 marks

Further Maths topic practice

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Name: _____ **Date:** _____ **Score:** _____ **/ 90**

1 A small smooth sphere is moving on a smooth horizontal floor when it strikes a fixed smooth vertical wall. Immediately before the impact the sphere has speed 6 m s^{-1} and its direction of motion makes an angle of 40° with the wall, as shown in the diagram.

The coefficient of restitution between the sphere and the wall is 0.5

Find

a. the speed of the sphere immediately after the impact,

b. the angle between the wall and the direction of motion of the sphere immediately after the impact.

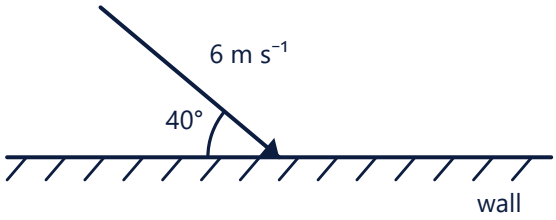


Diagram NOT accurately drawn

(5 marks)

Answer _____

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2 A small smooth sphere is moving on a smooth horizontal floor when it strikes a fixed smooth vertical wall. Immediately before the impact the direction of motion of the sphere makes an angle of 50° with the wall. Immediately after the impact the direction of motion of the sphere makes an angle of 30° with the wall, as shown in the diagram.

a. Find the coefficient of restitution between the sphere and the wall.

The speed of the sphere immediately before the impact is 5 m s^{-1}

b. Find the speed of the sphere immediately after the impact.

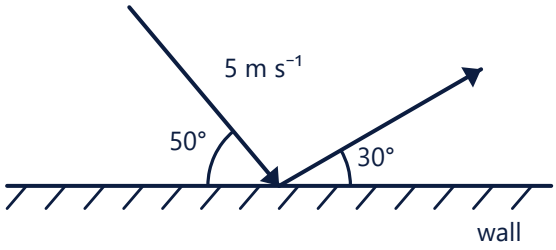


Diagram NOT accurately drawn

(5 marks)

Answer

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3 A smooth ball of mass 0.3 kg is moving on a smooth horizontal surface with speed 8 m s^{-1} when it strikes a fixed smooth vertical wall. Immediately before the impact the direction of motion of the ball makes an angle of 60° with the wall.

The coefficient of restitution between the ball and the wall is $\frac{1}{3}$

The ball is modelled as a particle.

a. Find the magnitude of the impulse exerted on the ball by the wall.

b. Find the kinetic energy lost by the ball in the impact.

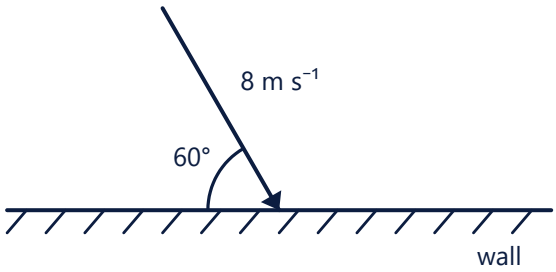


Diagram NOT accurately drawn

(6 marks)

Answer

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4 A smooth sphere S moving on a smooth horizontal plane strikes a fixed smooth vertical wall. Immediately before the impact, the direction of motion of S makes an angle α with the wall. Immediately after the impact, the direction of motion of S makes an angle β with the wall, as shown in the diagram. The coefficient of restitution between S and the wall is e, where $0 < e < 1$

a. Show that $\tan\beta = e\tan\alpha$

Given that $e = 0.6$ and $\beta = 25°$,

b. find the value of α,

c. find the angle through which the direction of motion of S is deflected by the impact.

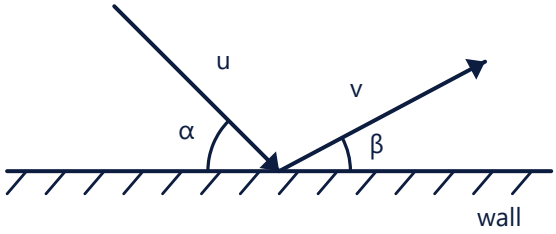


Diagram NOT accurately drawn

(7 marks)

Answer

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5 [In this question **i** and **j** are perpendicular unit vectors in a horizontal plane.]

A smooth puck of mass 0.5 kg is sliding on smooth horizontal ice. It strikes a fixed smooth vertical barrier. The barrier lies along a line parallel to **i**.

Immediately before the impact the velocity of the puck is $(5\mathbf{i} - 4\mathbf{j})$ m s^{-1}. The coefficient of restitution between the puck and the barrier is 0.75

a. Find the velocity of the puck immediately after the impact.

b. Find the impulse exerted on the puck by the barrier.

c. Find the kinetic energy lost by the puck in the impact.

(7 marks)

Answer

6 [In this question **i** and **j** are perpendicular unit vectors in a horizontal plane.]

A smooth sphere of mass 0.2 kg is moving on a smooth horizontal floor. It strikes a fixed smooth vertical wall which lies along a line parallel to **j**.

Immediately before the impact the velocity of the sphere is $(6\mathbf{i} + 5\mathbf{j})$ m s^{-1}. Immediately after the impact the velocity of the sphere is $(-4\mathbf{i} + 5\mathbf{j})$ m s^{-1}.

a. Find the coefficient of restitution between the sphere and the wall.

b. Find the magnitude of the impulse exerted on the sphere by the wall.

c. Find the angle through which the direction of motion of the sphere is deflected by the impact.

(7 marks)

Answer

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7 A small smooth sphere is moving on a smooth horizontal floor when it strikes a fixed smooth vertical wall. Immediately before the impact the sphere has speed u and its direction of motion makes an angle α with the wall. The coefficient of restitution between the sphere and the wall is $\frac{1}{2}$

As a result of the impact, the sphere loses $\frac{1}{3}$ of its kinetic energy.

a. Show that $\sin \alpha = \frac{2}{3}$

b. Find the angle between the wall and the direction of motion of the sphere immediately after the impact.

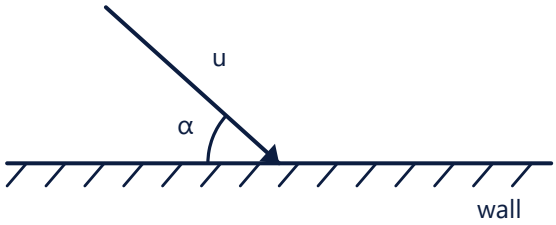


Diagram NOT accurately drawn

(7 marks)

Answer

8 A small smooth sphere is moving on a smooth horizontal floor when it strikes a fixed smooth vertical wall. Immediately before the impact the direction of motion of the sphere makes an angle α with the wall. The coefficient of restitution between the sphere and the wall is e.

The impact deflects the direction of motion of the sphere through 90°.

a. Show that $e \tan^2\alpha = 1$

Given that $e = \frac{1}{3}$,

b. find the value of α,

c. show that the sphere loses $\frac{2}{3}$ of its kinetic energy in the impact.

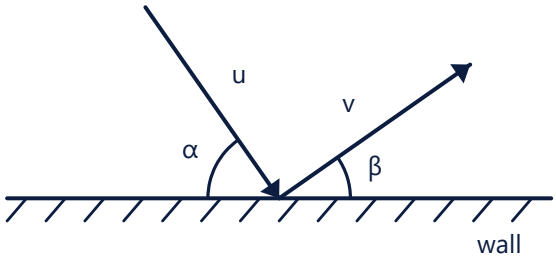


Diagram NOT accurately drawn

(8 marks)

Answer

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9 A small smooth ball of mass 0.2 kg is falling vertically. It strikes a fixed smooth plane which is inclined at 30° to the horizontal, as shown in the diagram. Immediately before the impact the ball has speed 7 m s^{-1}. Immediately after the impact the ball is moving horizontally. The coefficient of restitution between the ball and the plane is e.

a. Show that $e = \frac{1}{3}$

b. Find the speed of the ball immediately after the impact.

c. Find the magnitude of the impulse exerted on the ball by the plane.

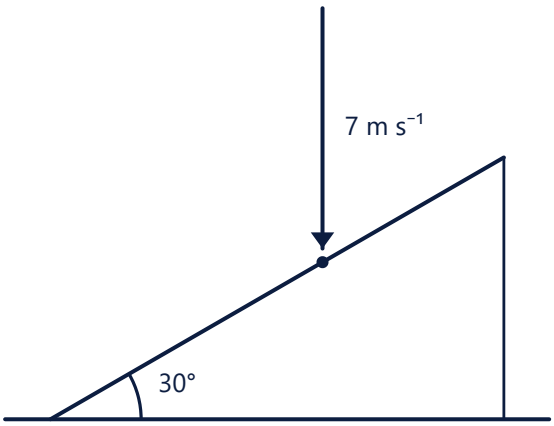


Diagram NOT accurately drawn

(8 marks)

Answer

10 [In this question **i** and **j** are perpendicular unit vectors in a horizontal plane.]

The corner of an ice rink is formed by two fixed smooth vertical barriers P and Q which meet at right angles. Barrier P lies along a line parallel to **i** and barrier Q lies along a line parallel to **j**, as shown in the diagram.

A puck of mass 0.17 kg slides on the smooth ice with velocity $(-6\mathbf{i} - 8\mathbf{j})$ m s^{-1}. It strikes P, then rebounds and strikes Q. The coefficient of restitution between the puck and each barrier is 0.5. The puck is modelled as a particle.

a. Find the velocity of the puck immediately after it strikes P.

b. Find the velocity of the puck immediately after it strikes Q.

c. Show that, after both impacts, the puck moves parallel to its original path but in the opposite direction.

d. Find the total kinetic energy lost in the two impacts.

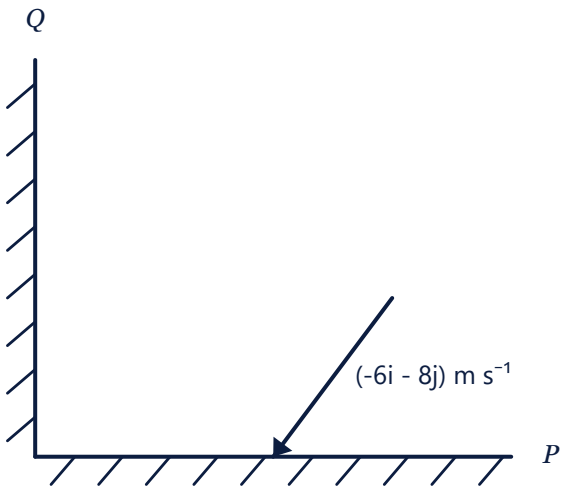


Diagram NOT accurately drawn

(9 marks)

Answer

11 [In this question **i** and **j** are perpendicular unit vectors in a horizontal plane.]

A smooth sphere of mass 0.4 kg is moving on a smooth horizontal floor with velocity $(7\mathbf{i} + \mathbf{j})$ m s^{-1}. It strikes a fixed smooth vertical wall which lies along a line parallel to the vector $(\mathbf{i} + \mathbf{j})$. The coefficient of restitution between the sphere and the wall is $\frac{1}{3}$

a. Show that the velocity of the sphere immediately after the impact is $(3\mathbf{i} + 5\mathbf{j})$ m s^{-1}.

b. Find the magnitude of the impulse exerted on the sphere by the wall.

c. Find the angle through which the direction of motion of the sphere is deflected by the impact.

(10 marks)

Answer

12 [In this question **i** and **j** are perpendicular unit vectors in a horizontal plane.]

A smooth ball of mass 0.25 kg is rolling on a smooth horizontal floor. It strikes a fixed smooth vertical wall. Immediately before the impact the velocity of the ball is (7**i** − **j**) m s^{-1}. Immediately after the impact the velocity of the ball is (2.2**i** + 5.4**j**) m s^{-1}. The ball is modelled as a particle.

a. Find the impulse exerted on the ball by the wall.

b. Explain why the wall lies along a line parallel to (4**i** + 3**j**).

c. Find the coefficient of restitution between the ball and the wall.

d. Find the percentage of the kinetic energy of the ball that is lost in the impact.

e. Find the angle between the wall and the direction of motion of the ball immediately after the impact.

(11 marks)

Answer _____

End of questions | Total 90 marks

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