

Topical questions | 38 questions

1. Question part 1/2 | 9231 May-June 2020 P3 V1 Q6

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9231 Further Mathematics Paper 3 - Momentum

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1. Question part 2/2 | 9231 May-June 2020 P3 V1 Q6

The particle P loses two-thirds of its kinetic energy in the impact.

(b) Find the value of α and the value of e .

[5]

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2. Question part 1/2 | 9231 May-June 2020 P3 V2 Q6

- 6 A particle P of mass m is moving with speed u on a fixed smooth horizontal surface. The particle strikes a fixed vertical barrier. At the instant of impact the direction of motion of P makes an angle α with the barrier. The coefficient of restitution between P and the barrier is e . As a result of the impact, the direction of motion of P is turned through 90° .

(a) Show that $\tan^2 \alpha = \frac{1}{e}$. [3]

[illegible]

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2. Question part 2/2 | 9231 May-June 2020 P3 V2 Q6

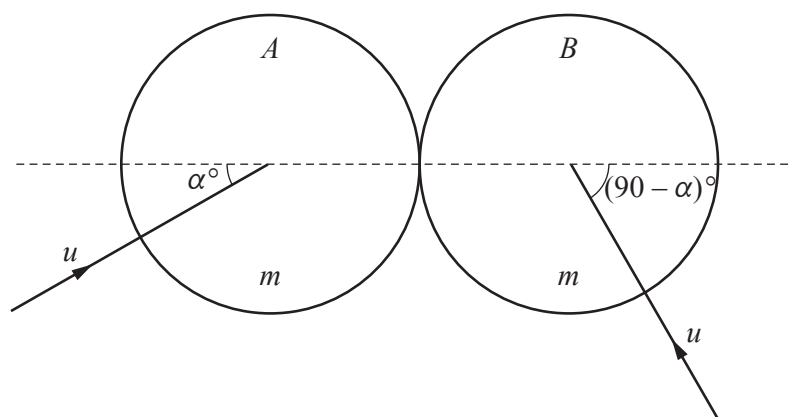
The particle P loses two-thirds of its kinetic energy in the impact.

(b) Find the value of α and the value of e .

[5]

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5



Immediately after the collision, B moves in a direction at right angles to the line of centres.

- (a) Show that $\tan \alpha = \frac{1+e}{1-e}$. [4]

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3. Question part 2/2 | 9231 May-June 2020 P3 V3 Q5

(b) Given that $\tan \alpha = 2$, find the speed of A after the collision.

[4]

[illegible]

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6 Two smooth spheres A and B have equal radii and masses m and $2m$ respectively. Sphere B is at rest on a smooth horizontal floor. Sphere A is moving on the floor with velocity u and collides directly with B . The coefficient of restitution between the spheres is e .

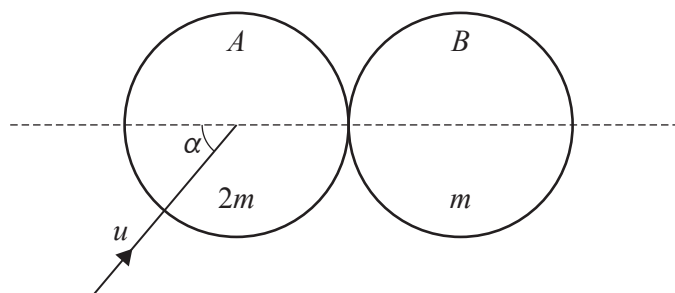
[illegible]

The coefficient of restitution between B and the wall is $\frac{2}{3}$. Immediately after B collides with the wall, the kinetic energy of A is $\frac{5}{32}$ of the kinetic energy of B .

[illegible]

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4. Question part 2/2 | 9231 Oct-Nov 2020 P3 V1 Q6



Find the speed of A after the collision.

[5]

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6. Question part 1/2 | 9231 Oct-Nov 2020 P3 V3 Q6

- 6 Two smooth spheres A and B have equal radii and masses m and $2m$ respectively. Sphere B is at rest on a smooth horizontal floor. Sphere A is moving on the floor with velocity u and collides directly with B . The coefficient of restitution between the spheres is e .

(a) Find, in terms of u and e , the velocities of A and B after the collision. [3]

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Subsequently, B collides with a fixed vertical wall which makes an angle θ with the direction of motion of B , where $\tan \theta = \frac{3}{4}$.

The coefficient of restitution between B and the wall is $\frac{2}{3}$. Immediately after B collides with the wall, the kinetic energy of A is $\frac{5}{32}$ of the kinetic energy of B .

(b) Find the possible values of e . [7]

[illegible]

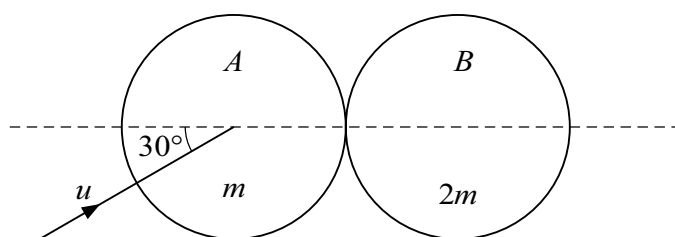
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6. Question part 2/2 | 9231 Oct-Nov 2020 P3 V3 Q6

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4



(a) Show that the speed of B after the collision is $\frac{\sqrt{3}}{6}u(1+e)$ and find the speed of A after the collision.

[6]

[illegible]

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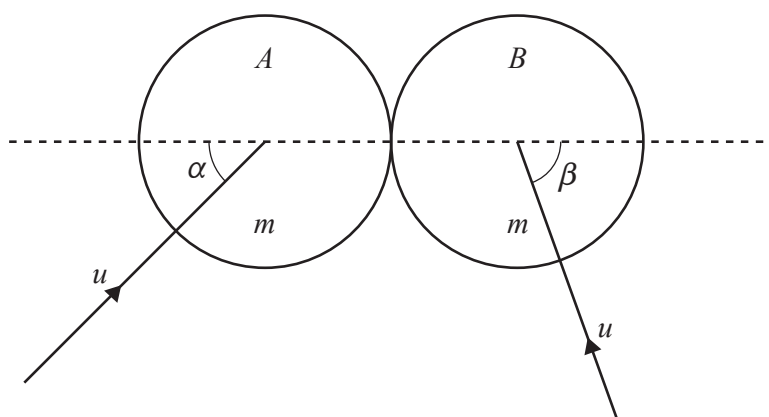
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7. Question part 2/2 | 9231 Specimen 2020 P3 Q4

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- (b)** Given that $e = \frac{1}{3}$, find the loss of kinetic energy as a result of the collision. [3]

[illegible]



(a) Show that the direction of motion of A after the collision is perpendicular to the line of centres.

[4]

[illegible]

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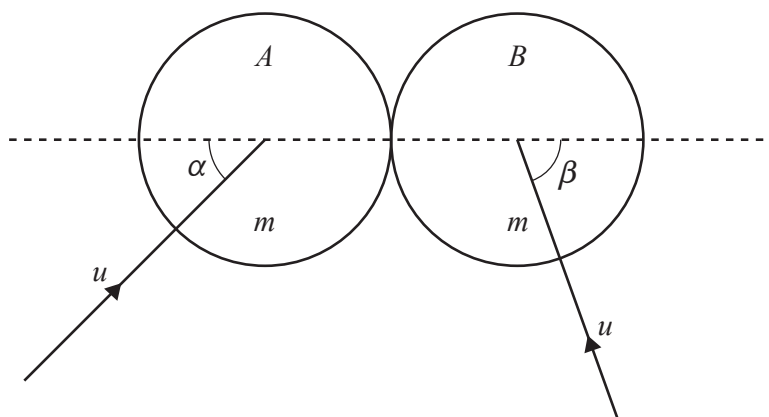
8. Question part 2/2 | 9231 May-June 2021 P3 V1 Q6

The total kinetic energy of the spheres after the collision is $\frac{3}{4}mu^2$.

(b) Find the value of α .

[4]

[illegible]



(a) Show that the direction of motion of A after the collision is perpendicular to the line of centres.

[4]

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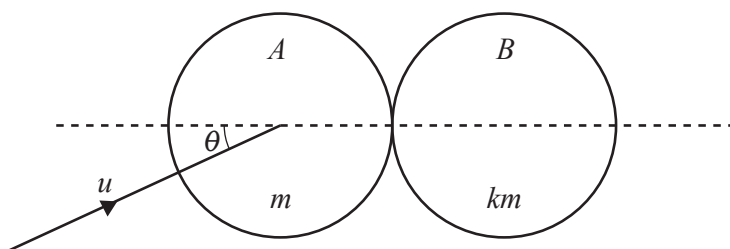
9. Question part 2/2 | 9231 May-June 2021 P3 V2 Q6

The total kinetic energy of the spheres after the collision is $\frac{3}{4}mu^2$.

(b) Find the value of α .

[4]

[illegible]



(a) Show that the speed of B after the collision is $\frac{4u \cos \theta}{3(1+k)}$. [3]

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10. Question part 2/2 | 9231 May-June 2021 P3 V3 Q6

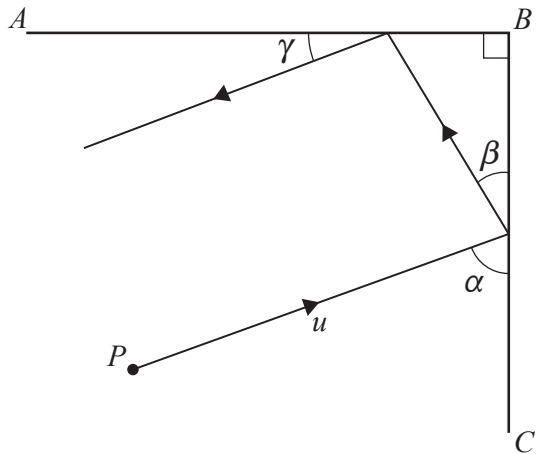
70% of the total kinetic energy of the spheres is lost as a result of the collision.

(b) Given that $\tan \theta = \frac{1}{3}$, find the value of k . [6]

[illegible]

11. Question part 1/3 | 9231 Oct-Nov 2021 P3 V1 Q7

7



The smooth vertical walls AB and CB are at right angles to each other. A particle P is moving with speed u on a smooth horizontal floor and strikes the wall CB at an angle α . It rebounds at an angle β to the wall CB . The particle then strikes the wall AB and rebounds at an angle γ to that wall (see diagram). The coefficient of restitution between each wall and P is e .

(a) Show that $\tan \beta = e \tan \alpha$. [3]

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(b) Express γ in terms of α and explain what this result means about the final direction of motion of P . [4]

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11. Question part 2/3 | 9231 Oct-Nov 2021 P3 V1 Q7

[illegible]

As a result of the two impacts the particle loses $\frac{8}{9}$ of its initial kinetic energy.

(c) Given that $\alpha + \beta = 90^\circ$, find the value of e and the value of $\tan \alpha$. [4]

[illegible]

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11. Question part 3/3 | 9231 Oct-Nov 2021 P3 V1 Q7

Additional Page

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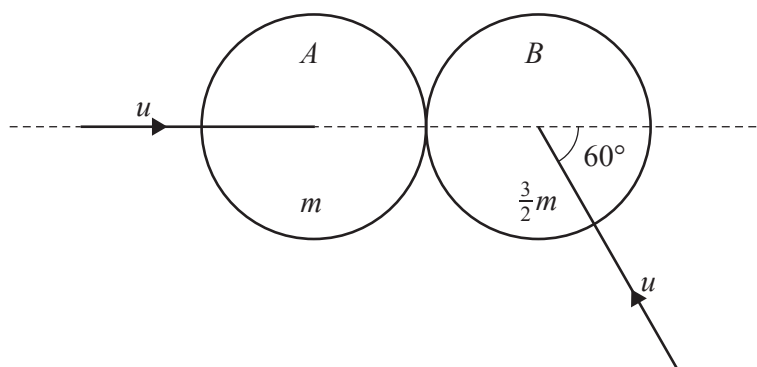
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2 A light spring AB has natural length a and modulus of elasticity $5mg$. The end A of the spring is attached to a fixed point on a smooth horizontal surface. A particle P of mass m is attached to the end B of the spring. The spring and particle P are at rest on the surface.

Find the value of k . [6]

[illegible]



(a) Find the angle through which the direction of motion of B is deflected by the collision. [6]

[illegible]

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13. Question part 2/2 | 9231 Oct-Nov 2021 P3 V2 Q5

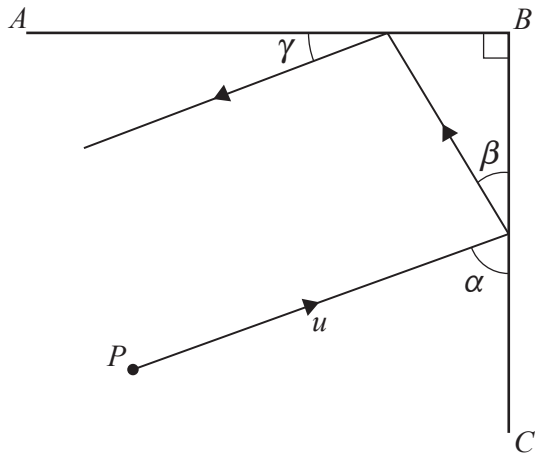
[illegible]

- (b)** Find the loss in the total kinetic energy of the system as a result of the collision. [3]

[illegible]

14. Question part 1/3 | 9231 Oct-Nov 2021 P3 V3 Q7

7



The smooth vertical walls AB and CB are at right angles to each other. A particle P is moving with speed u on a smooth horizontal floor and strikes the wall CB at an angle α . It rebounds at an angle β to the wall CB . The particle then strikes the wall AB and rebounds at an angle γ to that wall (see diagram). The coefficient of restitution between each wall and P is e .

(a) Show that $\tan \beta = e \tan \alpha$. [3]

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(b) Express γ in terms of α and explain what this result means about the final direction of motion of P . [4]

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14. Question part 2/3 | 9231 Oct-Nov 2021 P3 V3 Q7

As a result of the two impacts the particle loses $\frac{8}{9}$ of its initial kinetic energy.

(c) Given that $\alpha + \beta = 90^\circ$, find the value of e and the value of $\tan \alpha$. [4]

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14. Question part 3/3 | 9231 Oct-Nov 2021 P3 V3 Q7

Additional Page

If you use the following lined page to complete the answer(s) to any question(s), the question number(s) must be clearly shown.

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6 Two uniform smooth spheres A and B of equal radii have masses m and km respectively. The two spheres are on a horizontal surface. Sphere A is travelling with speed u towards sphere B which is at rest. The spheres collide. Immediately before the collision, the direction of motion of A makes an angle α with the line of centres. The coefficient of restitution between the spheres is $\frac{1}{2}$.

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15. Question part 2/2 | 9231 May-June 2022 P3 V1 Q6

After the collision, the kinetic energy of A is equal to the kinetic energy of B .

(b) Given that $\tan \alpha = \frac{2}{3}$, find the possible values of k . [5]

[illegible]

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6 Two uniform smooth spheres A and B of equal radii have masses m and km respectively. The two spheres are on a horizontal surface. Sphere A is travelling with speed u towards sphere B which is at rest. The spheres collide. Immediately before the collision, the direction of motion of A makes an angle α with the line of centres. The coefficient of restitution between the spheres is $\frac{1}{2}$.

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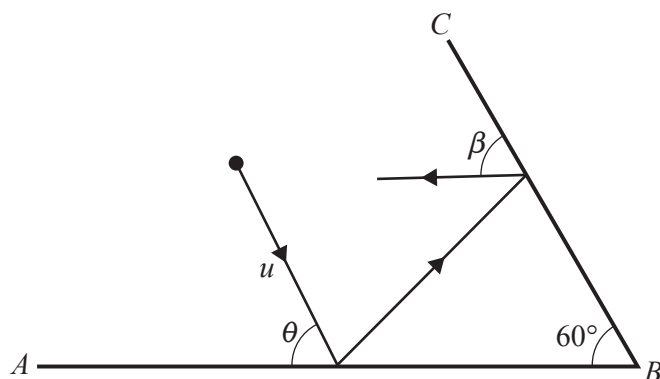
16. Question part 2/2 | 9231 May-June 2022 P3 V2 Q6

After the collision, the kinetic energy of A is equal to the kinetic energy of B .

(b) Given that $\tan \alpha = \frac{2}{3}$, find the possible values of k . [5]

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6



The kinetic energy of the particle after the first collision is 40% of its kinetic energy before the first collision.

- (a) Find the value of e . [4]

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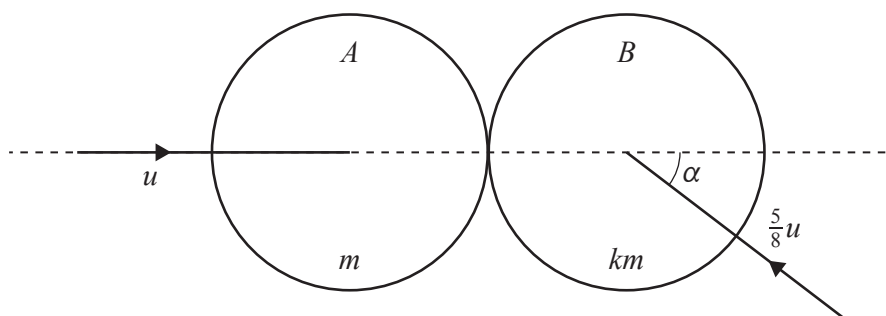
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(b) Find the size of angle β .

[4]

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6



Two uniform smooth spheres A and B of equal radii have masses m and km respectively. The two spheres are moving on a horizontal surface with speeds u and $\frac{5}{8}u$ respectively. Immediately before the spheres collide, A is travelling along the line of centres, and B 's direction of motion makes an angle α with the line of centres (see diagram). The coefficient of restitution between the spheres is $\frac{2}{3}$ and $\tan \alpha = \frac{3}{4}$.

After the collision, the direction of motion of B is perpendicular to the line of centres.

- (a)** Find the value of k . [4]

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18. Question part 2/2 | 9231 Oct-Nov 2022 P3 V1 Q6

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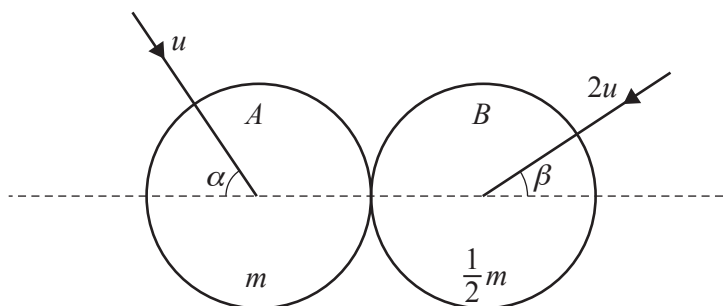
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(b) Find the loss in the total kinetic energy as a result of the collision.

[4]

[illegible]

7



(a) Find the component of the velocity of B parallel to the line of centres after the collision, giving your answer in terms of u and α . [4]

[illegible]

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19. Question part 2/3 | 9231 Oct-Nov 2022 P3 V2 Q7

The direction of motion of B after the collision is parallel to the direction of motion of A before the collision.

(b) Find the value of $\tan \alpha$. [5]

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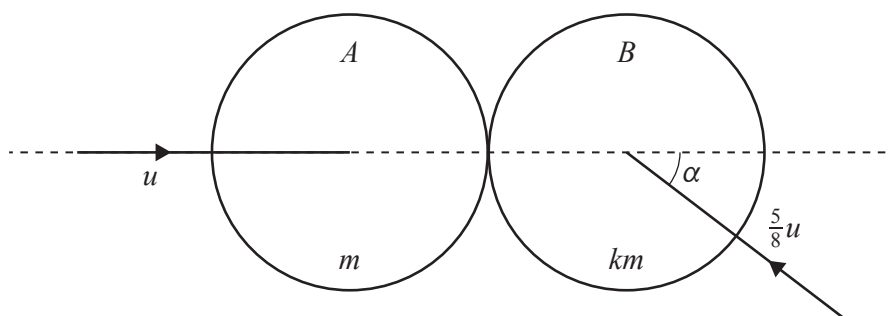
19. Question part 3/3 | 9231 Oct-Nov 2022 P3 V2 Q7

Additional page

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[illegible]

6



Two uniform smooth spheres A and B of equal radii have masses m and km respectively. The two spheres are moving on a horizontal surface with speeds u and $\frac{5}{8}u$ respectively. Immediately before the spheres collide, A is travelling along the line of centres, and B 's direction of motion makes an angle α with the line of centres (see diagram). The coefficient of restitution between the spheres is $\frac{2}{3}$ and $\tan \alpha = \frac{3}{4}$.

After the collision, the direction of motion of B is perpendicular to the line of centres.

- (a)** Find the value of k . [4]

[illegible]

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20. Question part 2/2 | 9231 Oct-Nov 2022 P3 V3 Q6

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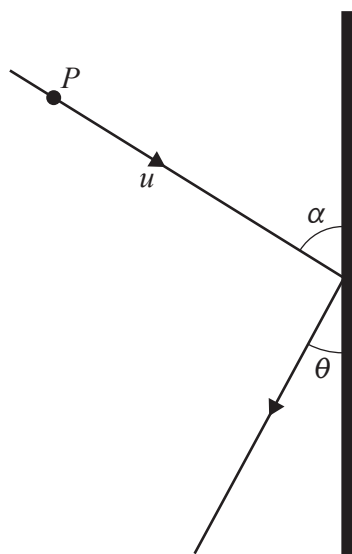
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(b) Find the loss in the total kinetic energy as a result of the collision.

[4]

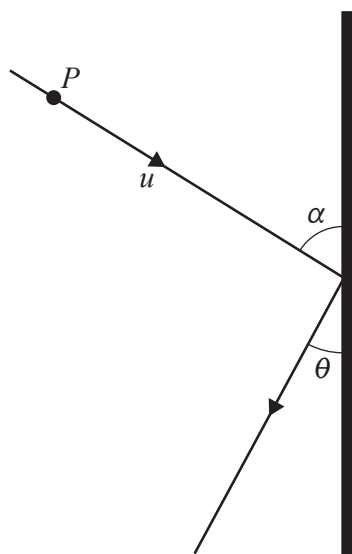
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Find the value of e .

[5]

[illegible]

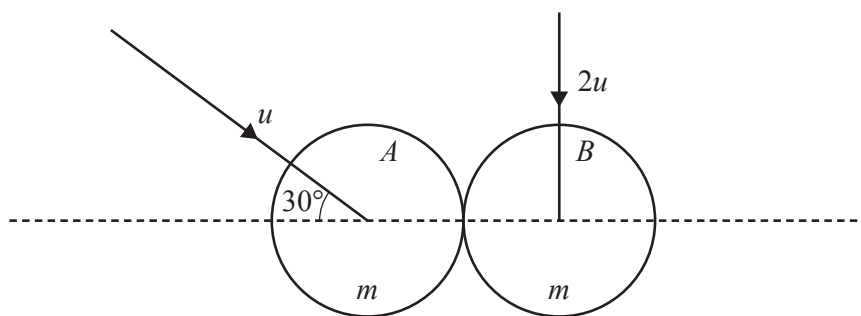


Find the value of e .

[5]

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4



(a) Find the value of e . [5]

[illegible]

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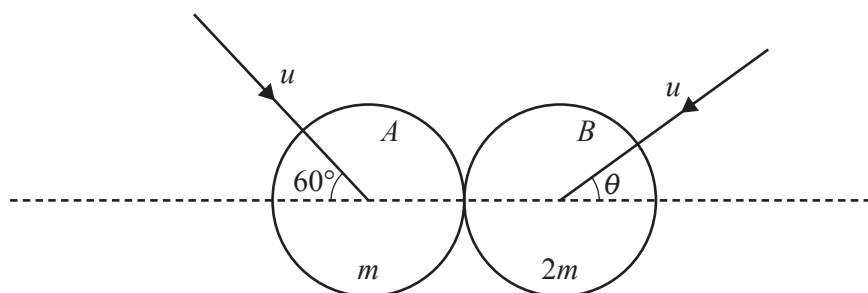
23. Question part 2/2 | 9231 May-June 2023 P3 V3 Q4

(b) Find the loss in the total kinetic energy of the spheres as a result of the collision.

[3]

[illegible]

1



After the collision, the component of the velocity of A along the line of centres is v and B moves perpendicular to the line of centres. Sphere A now has twice as much kinetic energy as sphere B .

- (a)** Show that $v = \frac{1}{2}u(4\cos\theta - 1)$. [1]

[illegible]

- (b) Find the value of $\cos \theta$. [4]

[illegible]

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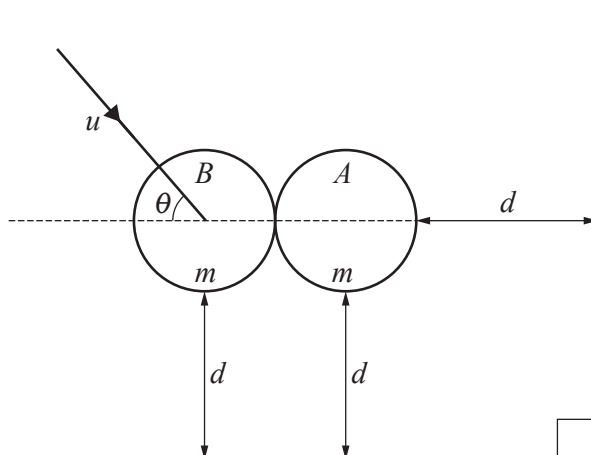
24. Question part 2/2 | 9231 Oct-Nov 2023 P3 V1 Q1

[illegible]

(c) Find the value of e .

[2]

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(a) Find the value of $\tan \theta$. [4]

[illegible]

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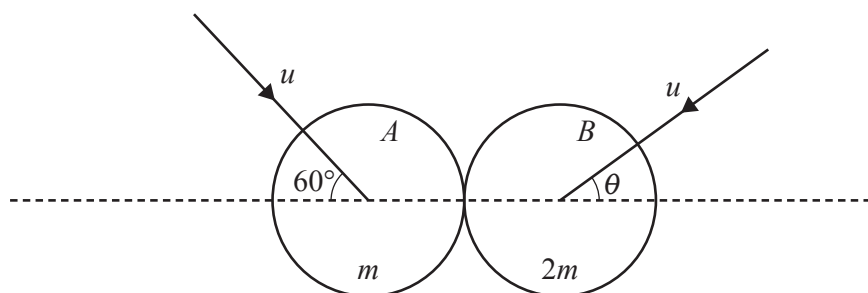
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25. Question part 2/2 | 9231 Oct-Nov 2023 P3 V2 Q4

(b) Find the percentage loss in the total kinetic energy of the spheres as a result of this collision. [3]

[illegible]

1



After the collision, the component of the velocity of A along the line of centres is v and B moves perpendicular to the line of centres. Sphere A now has twice as much kinetic energy as sphere B .

- (a)** Show that $v = \frac{1}{2}u(4\cos\theta - 1)$. [1]

[illegible]

- (b) Find the value of $\cos \theta$. [4]

[illegible]

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26. Question part 2/2 | 9231 Oct-Nov 2023 P3 V3 Q1

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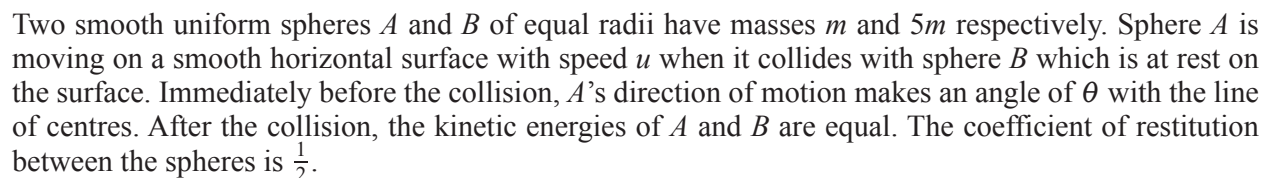
(c) Find the value of e .

[2]

This image shows a full page of white paper with horizontal dotted lines. The lines are evenly spaced and run across the width of the page, providing a guide for handwriting practice. There are no margins, text, or other markings on the page.

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[6]

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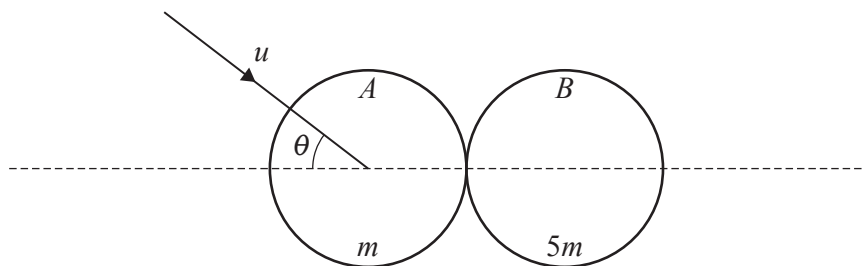
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27. Question part 2/2 | 9231 May-June 2024 P3 V1 Q1

[illegible]

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1

Find the value of $\tan \theta$. [6]This image shows a full page of white paper with horizontal dotted lines. The lines are evenly spaced and run across the width of the page, providing a guide for handwriting practice. There are no margins, text, or other markings on the page.

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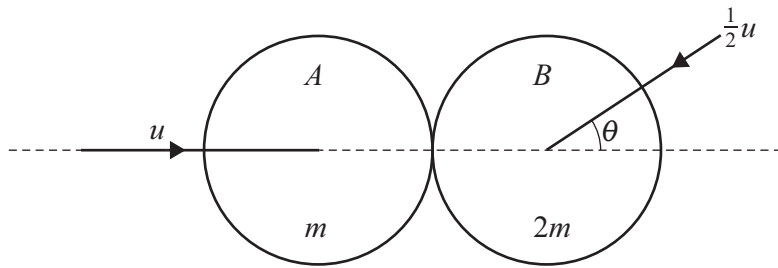
28. Question part 2/2 | 9231 May-June 2024 P3 V2 Q1

[illegible]

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29. Question | 9231 May-June 2024 P3 V3 Q1

1



As a result of the collision, the direction of motion of A is reversed and its speed is reduced to $\frac{1}{4}u$. The direction of motion of B again makes an angle θ with the line of centres, but on the opposite side of the line of centres. The speed of B is unchanged.

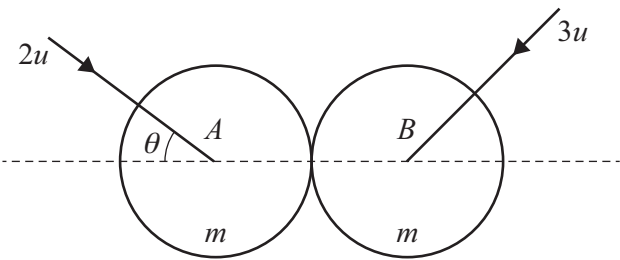
Find the value of the coefficient of restitution between the spheres. [4]

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30. Question part 1/2 | 9231 Oct-Nov 2024 P3 V2 Q3

3



The diagram shows two identical smooth uniform spheres A and B of equal radii and each of mass m . The two spheres are moving on a smooth horizontal surface when they collide with speeds $2u$ and $3u$ respectively. Immediately before the collision, A 's direction of motion makes an angle θ with the line of centres and B 's direction of motion is perpendicular to that of A . After the collision, B moves perpendicular to the line of centres. The coefficient of restitution between the spheres is $\frac{1}{3}$.

- (a) Find the value of $\tan \theta$. [3]

[illegible]

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30. Question part 2/2 | 9231 Oct-Nov 2024 P3 V2 Q3



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- This image shows a full page of white paper with horizontal dashed lines, typical of primary-ruled notebook paper. The lines are evenly spaced and run across the width of the page. There are no margins, text, or other markings present.

- [illegible]

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- (a) Show that $v_B = \frac{6}{5}u$. [3]

[illegible]

(b) Find the value of $\sin(\alpha + \beta)$. [6]

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31. Question part 2/2 | 9231 May-June 2025 P3 V1 Q6

[illegible]

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32. Question part 1/2 | 9231 May-June 2025 P3 V2 Q6

- 6** Two uniform smooth spheres A and B of equal radii have masses $2m$ and m respectively. Sphere A is moving in a straight horizontal line with speed u , and sphere B is stationary. Sphere A collides directly with B , and they both then move in the same direction with speeds v_A and v_B respectively. After the collision, the kinetic energy of B is $\frac{9}{2}$ times the kinetic energy of A .

(a) Show that $v_B = \frac{6}{5}u$. [3]

This image shows a blank sheet of white paper with horizontal ruling lines. The lines are evenly spaced and extend across the width of the page. There are no margins, text, or other markings on the paper.

Sphere B then collides with a fixed vertical barrier. Immediately before the collision, the direction of motion of B makes an angle α with the barrier. Immediately after the collision, the direction of motion of B makes an angle β with the barrier. The coefficient of restitution between B and the barrier is $\frac{4}{5}$. As a result of the collision, the velocity of B is reduced to $\frac{12}{25}\sqrt{5}u$.

(b) Find the value of $\sin(\alpha + \beta)$. [6]

[illegible]

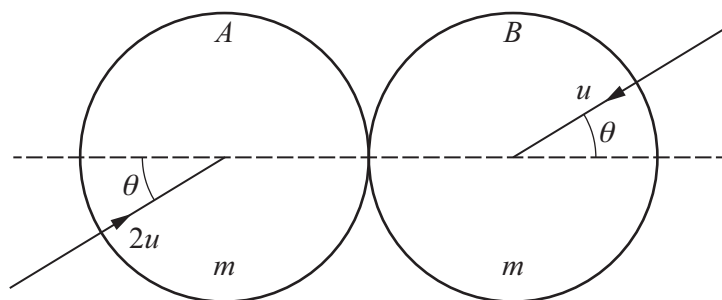
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32. Question part 2/2 | 9231 May-June 2025 P3 V2 Q6

[illegible]

6



(a) Find an expression for $\tan \theta$ in terms of e . [6]

[illegible]

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33. Question part 2/2 | 9231 May-June 2025 P3 V3 Q6

[illegible]

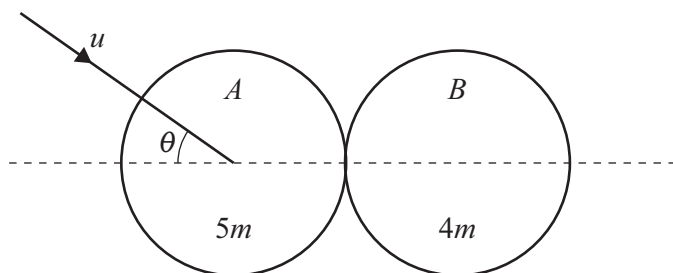
As a result of the collision, A moves in a direction which is perpendicular to the line of centres.

(b) Find the value of θ .

[2]

[illegible]

6



(a) Show that the speed of B after the collision is $\frac{5}{9}u(1+e)\cos\theta$. [3]

[illegible]

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34. Question part 2/2 | 9231 May-June 2025 P3 V4 Q6



After the collision the kinetic energy of A is equal to the kinetic energy of B .

(b) Given that $\tan \theta = \frac{2}{3}$, find the value of e .

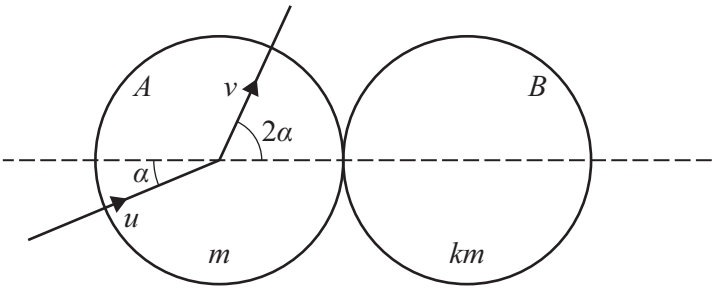
[6]

[illegible]

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36. Question part 1/2 | 9231 Oct-Nov 2025 P3 V2 Q5

- 5 Two uniform smooth spheres, A and B , of equal radii are on a horizontal surface. They have masses of m and km respectively. Sphere A is moving with speed u at an angle α with the line of centres when it collides with sphere B which is stationary. Immediately after the collision, sphere A moves with speed v at an angle 2α with the line of centres (see diagram).



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

- (a) Find v in terms of u . [2]

[illegible]

- (b)** Find the coefficient of restitution between the spheres in terms of k . [4]

This image shows a full page of a handwriting practice worksheet. It consists of ten sets of horizontal dashed lines spaced evenly down the page, providing a guide for letter height and placement. The background is plain white, and there are no other markings or text present.

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36. Question part 2/2 | 9231 Oct-Nov 2025 P3 V2 Q5

This image shows a full page of white paper with horizontal dotted lines. The lines are evenly spaced and run across the entire width of the page, providing a guide for handwriting practice. There are no margins, text, or other markings on the paper.

(c) Find the range of possible values of k .

[3]

[illegible]

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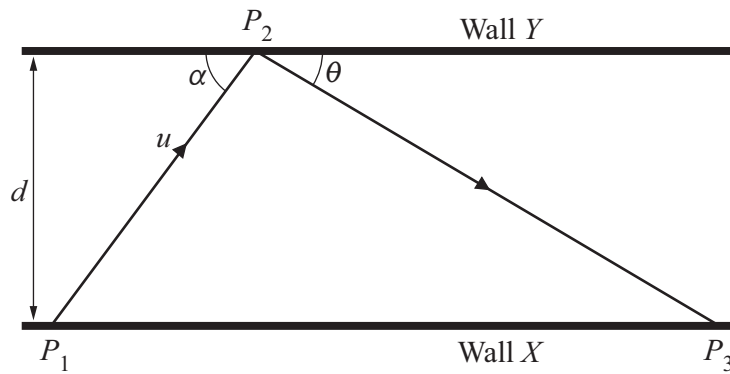
37. Question | 9231 Oct-Nov 2025 P3 V3 Q1

- 1 Two uniform smooth spheres A and B of equal radii have masses $4m$ and m respectively. Sphere B is at rest on a smooth horizontal surface. Sphere A is moving on the surface with speed u and collides directly with sphere B . After the collision, the momentum of A is three times the momentum of B .

Find the value of the coefficient of restitution e .

[4]

7



A particle Q is projected horizontally from the point P_1 on Wall X with speed u , and moves along the surface. The particle Q strikes Wall Y at the point P_2 . Immediately before the collision, the direction of motion of Q makes an angle α with Wall Y , where $\sin \alpha = \frac{4}{5}$. Immediately after the collision, the direction of motion of Q makes an angle θ with Wall Y . The particle Q then strikes Wall X at the point P_3 (see diagram).

Find, in terms of k , the coefficient of restitution between Q and Wall Y . [6]

This image shows a full page of white paper with horizontal dashed lines, typical of primary-ruled notebook paper. The lines are evenly spaced and run across the width of the page. There are no margins, text, or other markings on the paper.

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38. Question part 2/3 | 9231 Oct-Nov 2025 P3 V4 Q7

[illegible]

