Dynamics

(Linear Momentum)

TOPIC QUESTIONS (2)

Level	A Level
Subject	Physics
Exam Board	CIE
Paper Type	Multiple Choice

Time Allowed : 1Hour 10Min

1. Which of the following is a statement of the principle of conservation of momentum?

   A Momentum is the product of mass and velocity.

   B In an elastic collision, momentum is constant.

   C The momentum of an isolated system is constant.

   D The force acting on a body is proportional to its rate of change of momentum.

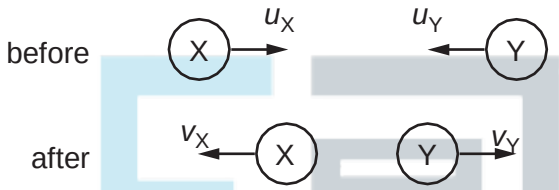
2 A molecule of mass m travelling horizontally with velocity u hits a vertical wall at right angles to the wall. It then rebounds horizontally with the same speed.

What is its change in momentum?

A zero **B** mu **C** $-mu$ **D** $-2mu$

3 Two balls X and Y approach each other along the same straight line and collide elastically.

Their speeds are u_X and u_Y respectively. After the collision they move apart with speeds v_X and v_Y respectively. Their directions are shown on the diagram.



Which of the following equations is correct?

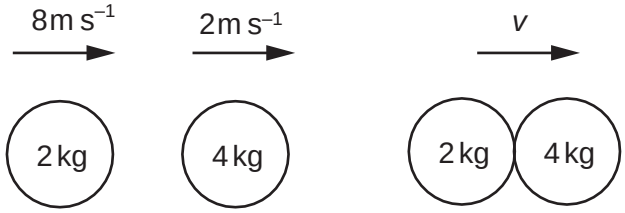
A $u_X + u_Y = v_X + v_Y$

B $u_X + u_Y = v_X - v_Y$

C $u_X - u_Y = v_X + v_Y$

D $u_X - u_Y = v_X - v_Y$

4 A ball of mass 2 kg travelling at $8\,m\,s^{-1}$ strikes a ball of mass 4 kg travelling at $2\,m\,s^{-1}$. Both balls are moving along the same straight line as shown.



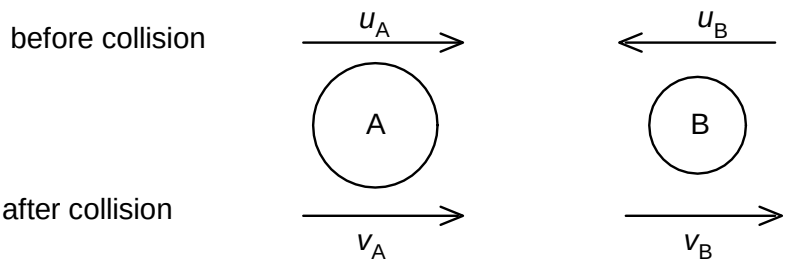
After collision, both balls move at the same velocity v.

What is the magnitude of the velocity v?

A $4\,m\,s^{-1}$ **B** $5\,m\,s^{-1}$ **C** $6\,m\,s^{-1}$ **D** $8\,m\,s^{-1}$

5 Two spheres A and B approach each other along the same straight line with speeds u_A and u_B.

The spheres collide and move off with speeds v_A and v_B, both in the same direction as the initial direction of sphere A, as shown below.



Which equation applies to an elastic collision?

A $u_A + u_B = v_B - V_a$

B $u_A - u_B = v_B - v_A$

C $u_A - u_B = v_B + v_A$

D $u_A + u_B = v_B + v_A$

6 Two spheres approach each other along the same straight line. Their speeds are u_1 and u_2 before collision. After the collision, the spheres separate with speeds v_1 and v_2 in the directions shown below.

Which equation must be correct if the collision is perfectly elastic?

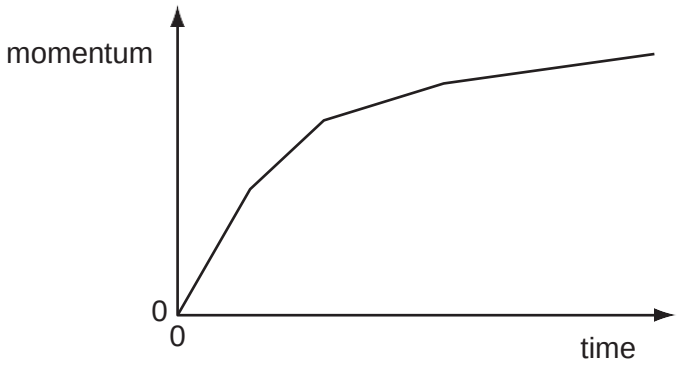
A $u_1 - u_2 = v_2 + v_1$

B $u_1 - u_2 = v_2 - v_1$

C $u_1 + u_2 = v_2 + v_1$

D $u_1 + u_2 = v_2 - v_1$

7 A car accelerates from rest. The graph shows the momentum of the car plotted against time.



What is the meaning of the gradient of the graph at a particular time?

A the resultant force on the car

B the velocity of the car

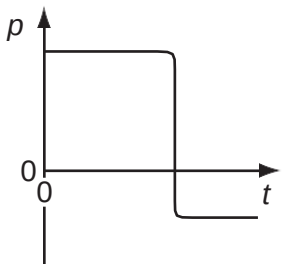
C the kinetic energy of the car

D the rate of change of kinetic energy of the car

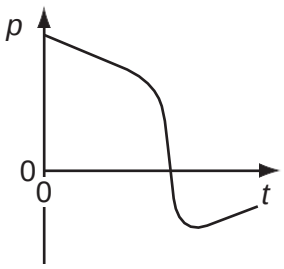
8 An ice-hockey puck slides along a horizontal, frictionless ice-rink surface. It collides inelastically with a wall at right angles to its path, and then rebounds along its original path.

Which graph shows the variation with time *t* of the momentum *p* of the puck?

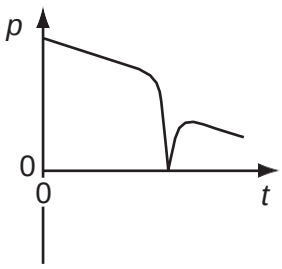
A



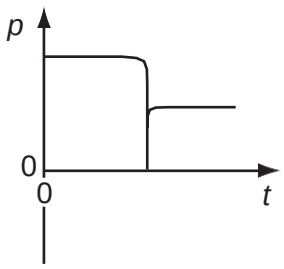
B



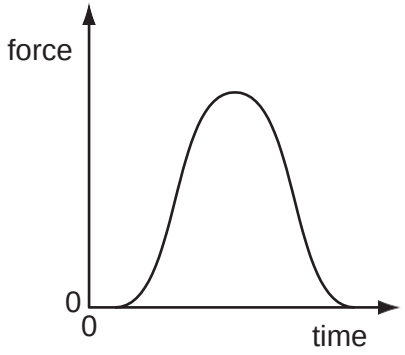
C



D



9 A golf ball is hit by a club. The graph shows the variation with time of the force exerted on the ball by the club.



Which quantity, for the time of contact, cannot be found from the graph?

A the average force on the ball

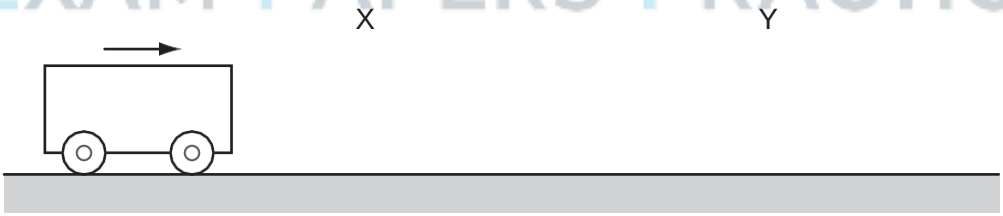
B the change in momentum of the ball

C the contact time between the ball and the club

D the maximum acceleration of the ball

10 A group of students investigating the principle of conservation of momentum use a small truck travelling over a frictionless surface.

Sand is dropped into the truck as it passes X. At Y, a trapdoor in the bottom of the truck opens and the sand falls out.



How does the velocity of the truck change when the sand is added to the truck at X and then leaves the truck at Y?

	at X	at Y
A	decreases	increases
B	decreases	stays the same
C	stays the same	increases
D	stays the same	stays the same

11. A stationary nucleus has nucleon number *A*.

The nucleus decays by emitting a proton with speed *v* to form a new nucleus with speed *u*. The

new nucleus and the proton move away from one another in opposite directions.

Which equation gives v in terms of A and u?

A $v = (\frac{A}{4} - 1\ u$

B $v = (A - 1)u$

C $v = Au$

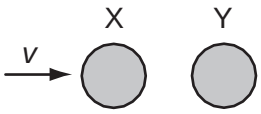
D $v = (A + 1)u$

12 Two spheres travel along the same line with velocities u_1 and u_2. They collide and after collision their velocities are v_1 and v_2.

Which collision is not elastic?

	u_1 / m s^{-1}	u_2 / m s^{-1}	v_1 / m s^{-1}	v_2 / m s^{-1}
A	2	-5	−5	−2
B	3	-3	0	6
C	3	-2	1	6
D	5	2	3	6

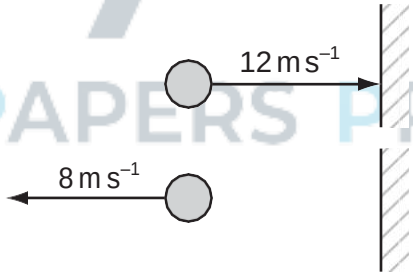
13 A particle X has speed v and collides with a stationary identical particle Y. The collision is perfectly elastic.



What are the speed and direction of motion of each of the two particles after the collision?

	X	Y
A	stationary	v to the right
B	$\frac{v}{2}$ to the right	$\frac{v}{2}$ to the right
C	$\frac{v}{2}$ to the left	$\frac{v}{2}$ to the right
D	v to the left	stationary

14 A ball of mass 0.5 kg is thrown against a wall at a speed of 12 m s^{-1}. It bounces back with a speed of 8 m s^{-1}. The collision lasts for 0.10 s.



What is the average force on the ball due to the collision?

A 0.2 N B 1 N C 20 N D 100 N

15 A lorry of mass 20 000 kg has a constant resultant force *F* acting on it.

It accelerates from 6.0 m s^{-1} to 30.0 m s^{-1} in a time of 300 s.

What is the change in momentum of the lorry and the value of *F*?

	change in momentum / N s	force *F* / N
A	48 000	160
B	480 000	1600
C	600 000	2000
D	600 000	20000

16 Two equal masses travel towards each other on a frictionless air track at speeds of 60 cm s^{-1} and30 cm s^{-1}. They stick together on impact.

What is the speed of the masses after impact?

A 15 cm s^{-1} **B** 20 cm s^{-1} **C** 30 cm s^{-1} **D** 45 cm s^{-1}

17 An object of mass 4.0 kg moving with a speed of 3.0 m s^{-1} strikes a stationary object in an inelastic collision.

Which statement is correct?

A After collision, the total kinetic energy is 18 J.

B After collision, the total kinetic energy is less than 18 J.

C Before collision, the total kinetic energy is 12 J.

D Before collision, the total kinetic energy is less than 12 J.

18 Which quantity has the same base units as momentum?

A density × energy

B density × volume × velocity

C pressure × area

D weight ÷ area

19 The diagram shows a particle X, with kinetic energy E_k, about to collide with a stationary particle Y.

Both particles have the same mass.

After colliding, X and Y travel onwards together as a single larger particle.

How much kinetic energy is lost in the collision?

A 0 B $\frac{E_k}{4}$ C $\frac{E_k}{2}$ D $\frac{3E_k}{4}$

20 Which quantities are conserved in an inelastic collision?

	kinetic energy	total energy	linear momentum
A	conserved	not conserved	conserved
B	conserved	not conserved	not conserved
C	not conserved	conserved	conserved
D	not conserved	conserved	not conserved

21 The momentum of an object of mass m is p.

Which quantity has the same base units as $\frac{p^2}{m}$?

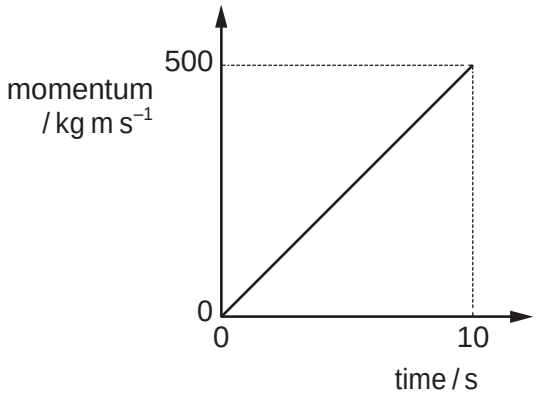
A energy

B force

C power

D velocity

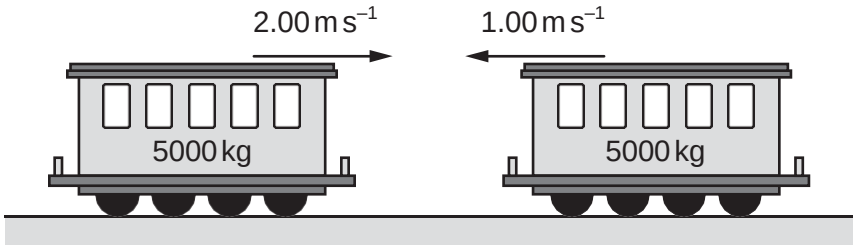
22. The graph shows how the momentum of a motorcycle changes with time.



What is the resultant force on the motorcycle?

A 50 N B 500 N C 2500 N D 5000 N

23. Two train carriages each of mass 5000 kg roll toward one another on a level track. One is travelling at 2.00 m s^{-1} and the other at 1.00 m s^{-1}, as shown.



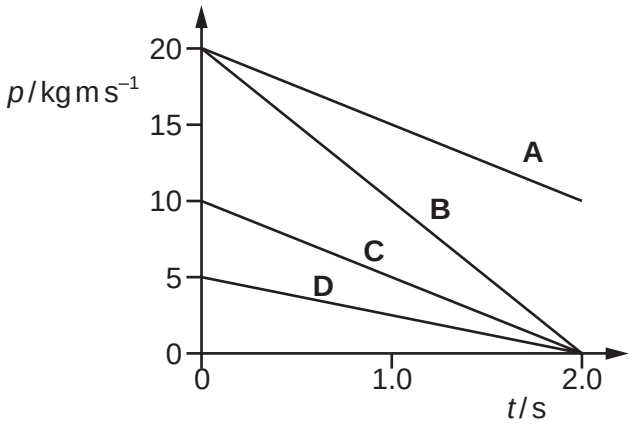
They collide and join together.

What is the kinetic energy lost during the collision?

A 1250 J B 7500 J C 11 250 J D 12 500 J

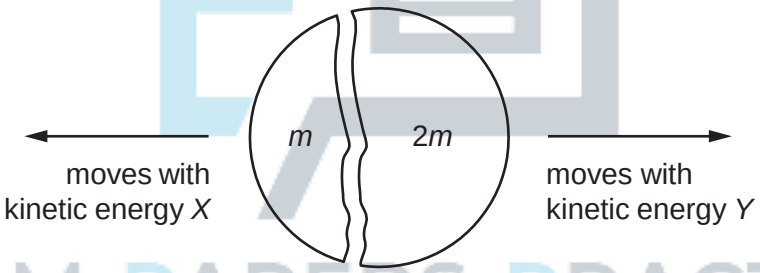
24. A resultant force of 10 N acts on a body for a time of 2.0 s.

Which graph could show the variation with time t of the momentum p of the body?



25. A stationary body explodes into two components of masses m and $2m$.

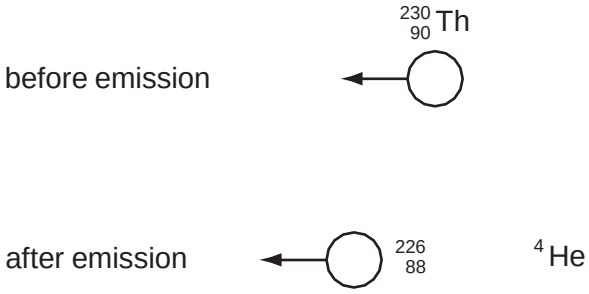
The components gain kinetic energies X and Y respectively.



What is the value of the ratio $\frac{X}{Y}$?

A $\frac{1}{4}$ B $\frac{1}{2}$ C $\frac{2}{1}$ D $\frac{4}{1}$

26. A moving thorium nucleus $^{230}_{90}Th$ spontaneously emits an α-particle. The nucleus formed is a radium nucleus $^{226}_{88}Ra$, as shown.



Which statement is correct?

A The kinetic energy of the α-particle equals the kinetic energy of the radium nucleus.

B The momentum of the α-particle equals the momentum of the radium nucleus.

C The total momentum before the emission equals the total momentum after the emission.

D The velocity of the α-particle equals the velocity of the radium nucleus.

27. An object of mass 20 kg is travelling at a constant speed of $6.0\,m\,s^{-1}$.

It collides with an object of mass 12 kg travelling at a constant speed of $15\,m\,s^{-1}$ in the opposite direction. The objects stick together.

What is the speed of the objects immediately after the collision?

A $1.9\,m\,s^{-1}$ B $9.0\,m\,s^{-1}$ C $9.4\,m\,s^{-1}$ D $21\,m\,s^{-1}$

28. A body of mass *m*, moving at velocity *v*, collides with a stationary body of the same mass andsticks to it.

Which row describes the momentum and kinetic energy of the two bodies after the collision?

	momentum	kinetic energy
A	mv	$\frac{1}{4}mv^2$
B	mv	$\frac{1}{8}mv^2$
C	$2mv$	$\frac{1}{2}mv^2$
D	$2mv$	mv^2

29. A molecule of mass *m* travelling horizontally with velocity *u* hits a vertical wall at right-angles to its velocity. It then rebounds horizontally with the same speed.

What is its change in momentum?

A zero B mu C $-mu$ D $-2mu$

30. The momentum of an object changes from 160 kg m s^{-1} to 240 kg m s^{-1} in 2 s.

What is the mean resultant force on the object during the change?

A 40 N B 80 N C 200 N D 400 N

31. A car accelerates in a straight line.

A graph of the momentum of the car is plotted against time.

What is evaluated by finding the gradient of the graph at a particular time?

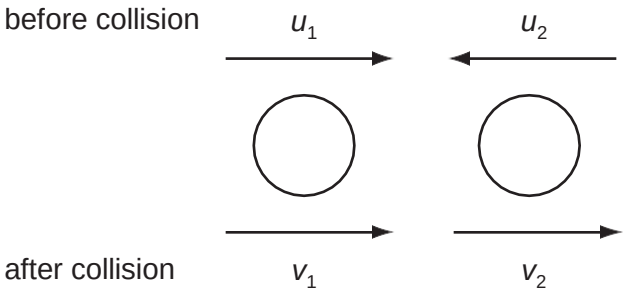
A the acceleration of the car

B the resultant force on the car

C the kinetic energy of the car

D the power supplied to the car

32. Two spheres approach each other along the same straight line. Their speeds are u_1 and u_2 before collision, and v_1 and v_2 after collision, in the directions shown below.



Which equation is correct if the collision is perfectly elastic?

A $u_1 - u_2 = v_2 + v_1$

B $u_1 - u_2 = v_2 - v_1$

C $u_1 + u_2 = v_2 + v_1$

D $u_1 + u_2 = v_2 - v_1$

33. Which is a statement of the principle of conservation of momentum?

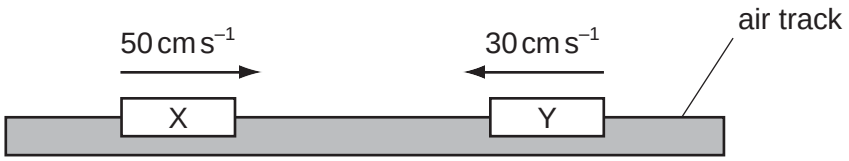
    a. Momentum is the product of mass and velocity.

    b. Momentum is conserved only in elastic collisions.

    c. Momentum is conserved by all bodies in a collision.

    d. Momentum is conserved providing no external forces act.

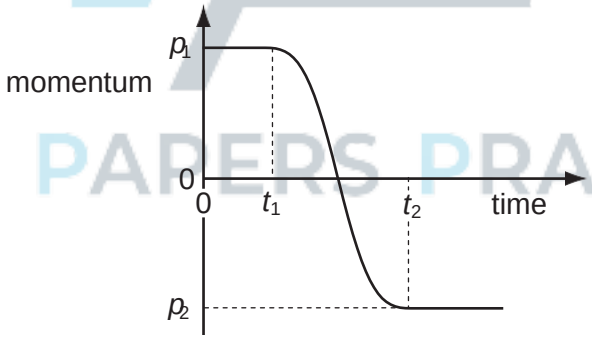
34. Two equal masses X and Y are moving towards each other on a frictionless air track as shown. The masses make an elastic collision.



Which row gives possible velocities for the two masses after the collision?

	velocity of X	velocity of Y
A	zero	20 cm s^{-1} to the right
B	10 cm s^{-1} to the right	10 cm s^{-1} to the right
C	20 cm s^{-1} to the left	zero
D	30 cm s^{-1} to the left	50 cm s^{-1} to the right

35. The graph shows the variation with time of the momentum of a ball as it is kicked in a straight line.



Initially, the momentum is p_1 at time t_1. At time t_2 the momentum is p_2.

What is the magnitude of the average force acting on the ball between times t_1 and t_2?

A $\frac{p_1 - p_2}{t_2}$ B $\frac{p_1 - p_2}{t_2 - t_1}$ C $\frac{p_1 + p_2}{t_2}$ D $\frac{p_1 + p_2}{t_2 - t_1}$

36. A molecule of mass m travelling at speed v hits a wall in a direction perpendicular to the wall. Thecollision is elastic.

What are the changes in the momentum and in the kinetic energy of the molecule caused by the collision?

	change in momentum	change in kinetic energy
A	0	0
B	0	mv^2
C	$2mv$	0
D	mv^2	0

37. Which statement is correct?

a. A ball lands on the ground and bounces. The kinetic energy changes sign, because the ballchanges direction.

b. A car drives up a slope at a steady speed. The power generated by the engine equals thepotential energy gained per unit time.

c. An electric heater can be 100% efficient.

d. It is impossible for momentum to be conserved in a collision.

38. Trolley X, moving along a horizontal frictionless track, collides with a stationary trolley Y. The two trolleys become attached and move off together.

Which statement about this interaction is correct?

A Some of the kinetic energy of trolley X is changed to momentum in the collision.

B Some of the momentum of trolley X is changed to kinetic energy in the collision.

C Trolley X loses some of its momentum as heat in the collision.

D Trolley X shares its momentum with trolley Y but some of its kinetic energy is lost.

39. A moving object strikes a stationary object. The collision is inelastic. The objects move off together.

Which row shows the possible values of total momentum and total kinetic energy for the system before and after the collision?

	total momentum before collision / kg m s^{-1}	total momentum after collision / kg m s^{-1}	total kinetic energy before collision / J	total kinetic energy after collision / J
A	6	2	90	30
B	6	6	30	90
C	6	6	90	30
D	6	6	90	90

40. Two balls X and Y are moving towards each other with speeds of 5 m s^{-1} and 15 m s^{-1} respectively.

They make a perfectly elastic head-on collision and ball Y moves to the right with a speed of 7 m s^{-1}.

What is the speed and direction of ball X after the collision?

A 3 m s^{-1} to the left

B 13 m s^{-1} to the left

C 3 m s^{-1} to the right

D 13 m s^{-1} to the right

41. Two railway trucks of masses m and $3m$ move towards each other in opposite directions withspeeds $2v$ and v respectively. These trucks collide and stick together.

What is the speed of the trucks after the collision?

A $\frac{v}{4}$ B $\frac{v}{2}$ C v D $\frac{5v}{4}$

42. Which is a statement of the principle of conservation of momentum?

A A force is equal to the rate of change of momentum of the body upon which it acts.

B In a perfectly elastic collision, the relative momentum of the bodies before impact is equal to their relative momentum after impact.

C The momentum of a body is the product of the mass of the body and its velocity.

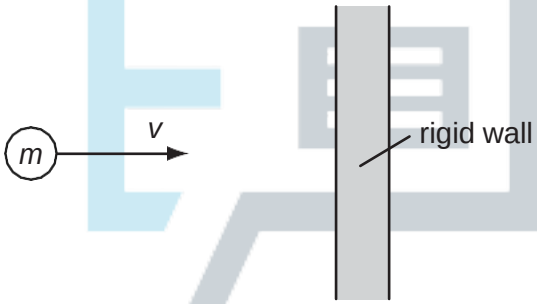
D The total momentum of a system of interacting bodies remains constant, providing no external force acts.

43. Two equal masses travel towards each other on a frictionless air track at speeds of 60 cm s^{-1} and 40 cm s^{-1}. They stick together on impact.

What is the speed of the masses after impact?

A 10 cm s^{-1} B 20 cm s^{-1} C 40 cm s^{-1} D 50 cm s^{-1}

44. A particle of mass *m* strikes a vertical rigid wall perpendicularly from the left with velocity *v*.



If the collision is perfectly elastic, the total change in momentum of the particle that occurs as a result of the collision is

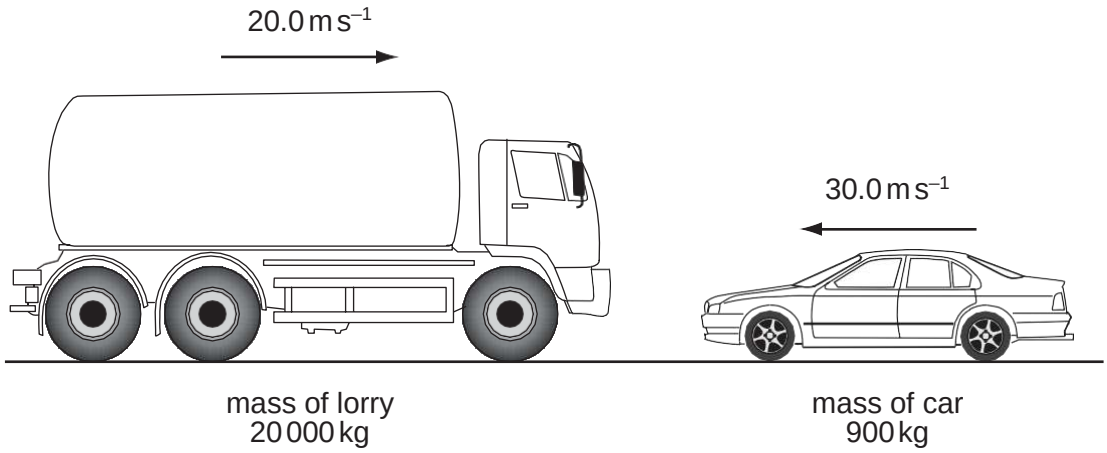
A $2mv$ to the right.

B $2mv$ to the left.

C mv to the right.

D mv to the left.

45. The diagram shows a situation just before a head-on collision. A lorry of mass 20 000 kg is travelling at 20.0 m s^{-1} towards a car of mass 900 kg travelling at 30.0 m s^{-1} towards the lorry.



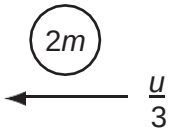
What is the magnitude of the total momentum?

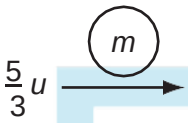
A 373 kN s B 427 kN s C 3600 kN s D 4410 kN s

46. The diagram shows two spherical masses approaching each other head-on at an equal speed u. One is of mass m and the other of mass $2m$.

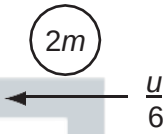
Which diagram, showing the situation after the collision, is not consistent with the principle of conservation of momentum?

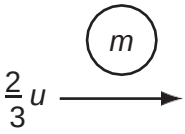
A



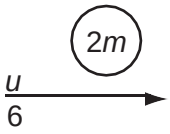


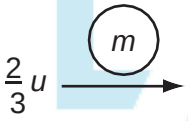
B



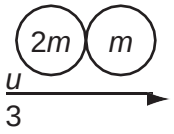


C





D



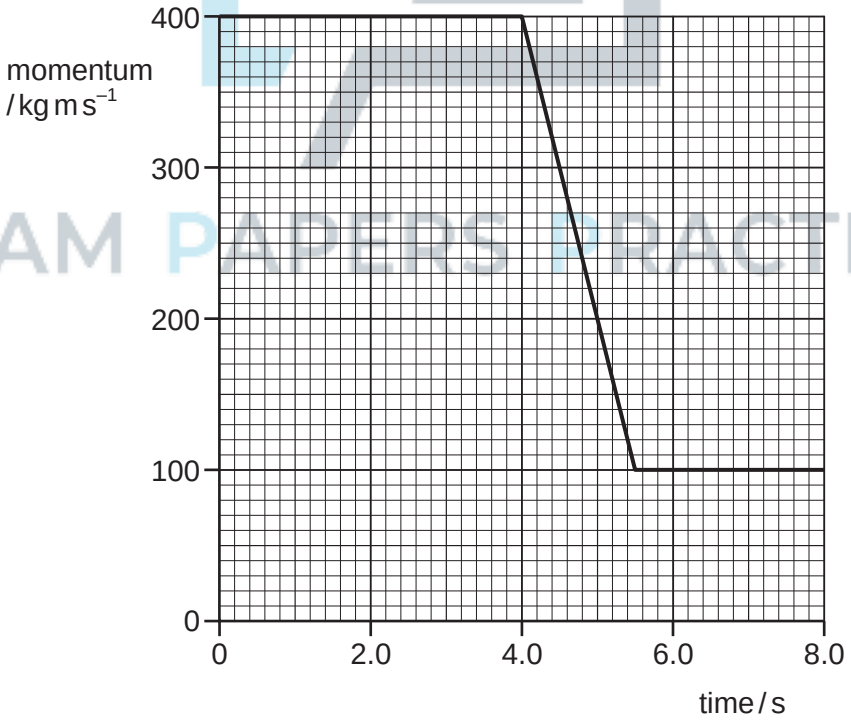
the spheres stick together

47. A molecule of mass m travelling at speed v hits a wall in a direction perpendicular to the wall. The collision is elastic.

What are the changes in the kinetic energy and in the momentum of the molecule caused by the collision?

	change in momentum	change in kinetic energy
A	0	0
B	0	mv^2
C	$2mv$	0
D	mv^2	0

48. The graph shows the momentum of a cyclist over a period of 8.0 s.

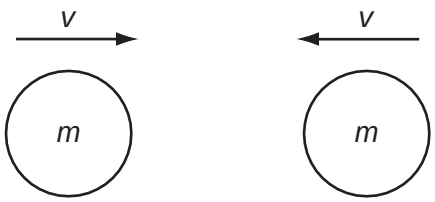


At time 4.0 s, she applies the brakes.

What is the resultant force on the cyclist during the period when the brakes are applied?

A 55 N B 200 N C 270 N D 450 N

49. Two similar spheres, each of mass *m* and travelling with speed *v*, are moving towards each other.



The spheres have a head-on elastic collision.

Which statement is correct?

A The spheres stick together on impact.

B The total kinetic energy after impact is mv^2.

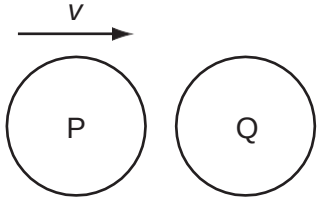
C The total kinetic energy before impact is zero.

D The total momentum before impact is $2mv$.

50. Which row correctly states whether momentum and kinetic energy are conserved in an inelastic collision in which there are no external forces?

	momentum	kinetic energy
A	conserved	conserved
B	conserved	not conserved
C	not conserved	conserved
D	not conserved	not conserved

51. The diagram shows a particle P, travelling at speed v, about to collide with a stationary particle Q of the same mass. The collision is perfectly elastic.



Which statement describes the motion of P and of Q immediately after the collision?

A P rebounds with speed $\frac{1}{2}$ v and Q acquires speed $\frac{1}{2}$ v.

B P rebounds with speed v and Q remains stationary.

C P and Q both travel in the same direction with speed $\frac{1}{2}$ v.

D P comes to a standstill and Q acquires speed v.

52. A body, initially at rest, explodes into two masses M_1 and M_2 that move apart with speeds v_1 and v_2 respectively.

What is the ratio $\frac{v_1}{v_2}$?

A $\frac{M_1}{M_2}$ B $\frac{M_2}{M_1}$ C $\sqrt{\frac{M_1}{M_2}}$ D $\sqrt{\frac{M_2}{M_1}}$

53. Two experiments are carried out using two trolleys of equal mass. All moving parts of the trolleys are frictionless, as is the surface that the trolleys move over. In both experiments, trolley X moves towards trolley Y, which is initially stationary.

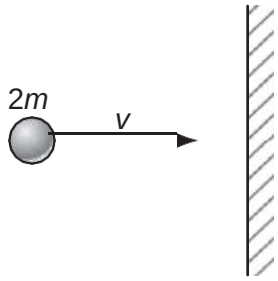
After the collision in experiment 1, X is stationary and Y moves off to the right.

After the collision in experiment 2, the trolleys join and move off together.

What types of collision occur in these experiments?

	experiment 1	experiment 2
A	elastic	elastic
B	elastic	inelastic
C	inelasti	elastic
D	inelastic	inelastic

54. A particle of mass $2m$ and velocity v strikes a wall.



The particle rebounds along the same path after colliding with the wall. The collision is inelastic.

What is a possible change in the momentum of the ball during the collision?

A mv B $2mv$ C $3mv$ D $4mv$

55. The diagram shows two identical spheres X and Y.

Initially, X moves with speed v directly towards Y. Y is stationary. The spheres collide elastically.

What happens?

	X	
A	moves with speed $\frac{1}{2}$ v to the right	moves with speed $\frac{1}{2}$ v to the right
B	moves with speed v to the left	remains stationary
C	moves with speed $\frac{1}{2}$ v to the left	moves with speed $\frac{1}{2}$ v to the right
D	stops	moves with speed v to the right

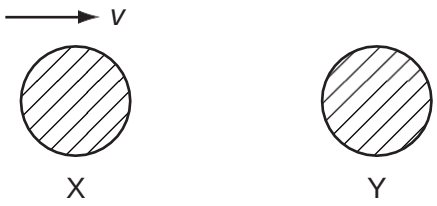
56. The diagram shows the masses and velocities of two trolleys about to collide.

After the impact they move off together.

What is the total kinetic energy of the trolleys after the collision?

A 1.3 J B 12 J C 18 J D 19 J

57. The diagram shows two identical spheres X and Y.

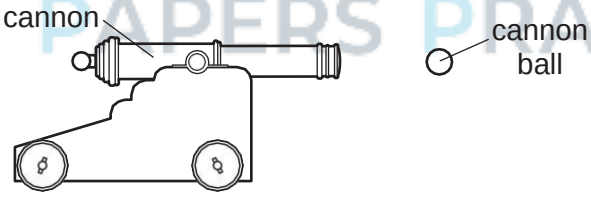


Initially X moves with speed v directly towards Y. Y is stationary. The spheres collide elastically.

What happens?

	X	
A B	moves with speed $\frac{1}{2}$v to the right	moves with speed $\frac{1}{2}$v to the right
C	moves with speed v to the left	remains stationary
D	moves with speed $\frac{1}{2}$v to the left	moves with speed $\frac{1}{2}$v to the right
	stops	moves with speed v to the right

58. The diagram shows a cannon ball fired from a cannon.



The mass of the cannon is 1000 kg and the mass of the cannon ball is 10 kg.

The recoil velocity of the cannon is 5 m s^{-1} horizontally.

What is the horizontal velocity of the cannon ball?

A 200 m s^{-1} B 500 m s^{-1} C 2000 m s^{-1} D 5000 m s^{-1}

59. In perfectly elastic collisions between two atoms, it is always true to say that

A the initial speed of one atom will be the same as the final speed of the other atom.

B the relative speed of approach between the two atoms equals their relative speed of separation.

C the total momentum must be conserved, but a small amount of the total kinetic energy may be lost in the collision.

D whatever their initial states of motion, neither atom can be stationary after the collision.

60. An isolated system consists of two bodies on which no external forces act. The two bodies collidewith each other and stick together on impact.

Which row correctly compares the total kinetic energy and the total momentum of the bodies before and after the collision?

	total kinetic energy before and after the collision	total momentum before and after the collision
A	different	different
B	different	the same
C	the same	different
D	the same	the same