Hong Kong Diploma of Secondary Education Examination

Physics – Compulsory part (必修部分)

Section A – Heat and Gases (熱和氣體)
1. Temperature, Heat and Internal energy (溫度、熱和內能)
2. Transfer Processes (熱轉移過程)
3. Change of State (形態的改變)
4. General Gas Law (普適氣體定律)
5. Kinetic Theory (分子運動論)

Section B – Force and Motion (力和運動)
1. Position and Movement (位置和移動)
2. Newton's Laws (牛頓定律)
3. Moment of Force (力矩)
4. Work, Energy and Power (作功、能量和功率)
5. Momentum (動量)
6. Projectile Motion (拋體運動)
7. Circular Motion (圓周運動)
8. Gravitation (引力)

Section C – Wave Motion (波動)
1. Wave Propagation (波的推進)
2. Wave Phenomena (波動現象)
3. Reflection and Refraction of Light (光的反射及折射)
4. Lenses (透鏡)
5. Wave Nature of Light (光的波動特性)
6. Sound (聲音)

Section D – Electricity and Magnetism (電和磁)
1. Electrostatics (靜電學)
2. Electric Circuits (電路)
3. Domestic Electricity (家居用電)
4. Magnetic Field (磁場)
5. Electromagnetic Induction (電磁感應)
6. Alternating Current (交流電)

Section E – Radioactivity and Nuclear Energy (放射現象和核能)
1. Radiation and Radioactivity (輻射和放射現象)
2. Atomic Model (原子模型)
3. Nuclear Energy (核能)

Physics – Elective part (選修部分)

Elective 1 – Astronomy and Space Science (天文學和航天科學)
1. The universe seen in different scales (不同空間標度下的宇宙面貌)
2. Astronomy through history (天文學的發展史)
3. Orbital motions under gravity (重力下的軌道運動)
4. Stars and the universe (恆星和宇宙)

Elective 2 – Atomic World (原子世界)
1. Rutherford's atomic model (盧瑟福原子模型)
2. Photoelectric effect (光電效應)
3. Bohr's atomic model of hydrogen (玻爾的氫原子模型)
4. Particles or waves (粒子或波)
5. Probing into nano scale (窺探納米世界)

Elective 3 – Energy and Use of Energy (能量和能源的使用)
1. Electricity at home (家居用電)
2. Energy efficiency in building (建築的能源效率)
3. Energy efficiency in transportation (運輸業的能源效率)
4. Non-renewable energy sources (不可再生能源)
5. Renewable energy sources (可再生能源)

Elective 4 – Medical Physics (醫學物理學)
1. Making sense of the eye (眼的感官)
2. Making sense of the ear (耳的感官)
3. Medical imaging using non-ionizing radiation (非電離輻射醫學影像學)
4. Medical imaging using ionizing radiation (電離輻射醫學影像學)

FM5 : Momentum

The following list of formulae may be found useful :

Gravitational potential energy	$E_P = m g h$
Kinetic energy	$E_K = \frac{1}{2} m v^2$
Mechanical power	$P = F v = \frac{W}{t}$
Force	$F = m \frac{\Delta v}{\Delta t} = \frac{\Delta p}{\Delta t}$

Use the following data wherever necessary :

Acceleration due to gravity $g = 9.81\ \text{m s}^{-2}$ (close to the Earth)

Part A : HKCE examination questions

1. **< HKCE 1980 Paper II - 1 >**

When a constant unbalanced force is applied to a particle, which of the following will change with time ?

(1) The acceleration of the particle
(2) The momentum of the particle
(3) The kinetic energy of the particle

A. (1) only
B. (3) only
C. (1) & (2) only
D. (2) & (3) only

2. **< HKCE 1980 Paper II - 2 >**

A ball is dropped from a height h above the ground. Each time it hits the ground, one-half of the original kinetic energy is lost. How high will the ball rise above the ground after the second impact ?

A. $\frac{h}{8}$
B. $\frac{h}{4}$
C. $\frac{h}{2}$
D. $\frac{h}{\sqrt{2}}$

3. **< HKCE 1980 Paper II - 6 >**

Two objects P and Q of mass 2 kg and 3 kg respectively have the same momentum. They are then subjected to the same constant resisting force and gradually brought to rest. What is the ratio of the stopping distance of P to that of Q ?

A. 4 : 9
B. 2 : 3
C. 3 : 2
D. 9 : 4

4. **< HKCE 1982 Paper II - 5 >**

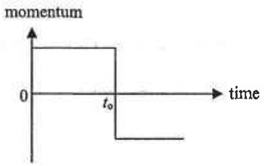
The diagram shows a gas molecule of mass m colliding with the wall of a container at a speed of 2 m s^{-1} and bounding back with the same speed. Which of the following is/are true ?

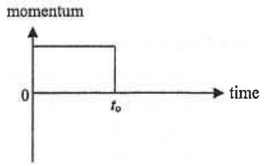
(1) The kinetic energy of the particle before and after the collision remains unchanged.
(2) The velocity of the particle before and after the collision remains unchanged.
(3) The momentum of the particle before and after the collision remains unchanged.

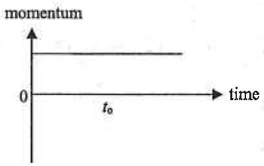
A. (1) only
B. (3) only
C. (1) & (2) only
D. (2) & (3) only

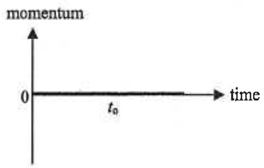
5. **< HKCE 1983 Paper II - 4 >**

A system consists of two identical masses travelling in opposite directions with equal speed. Suppose they collide elastically at time t_o. Which of the following graphs correctly shows the total momentum of the system before and after the collision ?

A.


B.


C.


D.


6. **< HKCE 1983 Paper II - 5 >**

A trolley of mass 1 kg travelling at 2 m s^{-1} on a smooth horizontal plane has a lump of plasticine dropped from a height 5 m onto it. If the mass of the plasticine is 2 kg, the velocity of the loaded trolley will be

A. 0.67 m s^{-1}
B. 1.00 m s^{-1}
C. 1.50 m s^{-1}
D. 1.33 m s^{-1}

7. **< HKCE 1983 Paper II - 10 >**

A particle is in motion with a constant force acting on it. Which of the following physical quantities will be changing during the time when the force is acting ?

(1) acceleration of the particle
(2) momentum of the particle
(3) kinetic energy of the particle

A. (1) only
B. (3) only
C. (1) & (2) only
D. (2) & (3) only

8. **< HKCE 1984 Paper II - 7 >**

A basketball falls freely from rest and hits the ground. It then rebounds to 1/4 of its original height. Neglecting air resistance, which of the following statements about the basketball is/are correct ?

(1) Its kinetic energy just before collision is four times its kinetic energy just after collision.
(2) Its potential energy just before collision is four times its potential energy just after collision.
(3) The speed just before collision is two times the speed just after collision.

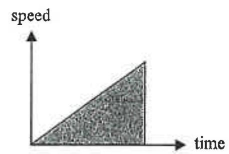
A. (1) only
B. (2) only
C. (2) & (3) only
D. (1) & (3) only

9. **< HKCE 1985 Paper II - 4 >**

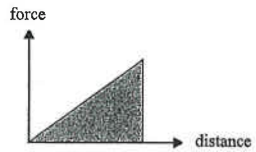
A ball of mass 2 kg drops from rest to the ground from a height 5 m and rebounds to the same height. If the time of duration of the impact between the ball and the ground is 0.2 s, what is the force acting on the ball by the ground ?
(Take the acceleration due to gravity be 10 m s^{-2})

A. 20 N
B. 100 N
C. 200 N
D. 220 N

10. **< HKCE 1985 Paper II - 3 >**



I



II

What physical quantity does the area of the shaded portion of each of the above graphs represent ?

	I	II
A.	acceleration	energy
B.	distance	power
C.	acceleration	change of momentum
D.	distance	energy

11. **< HKCE 1986 Paper II - 4 >**

Which of the following is a vector quantity with correct unit ?

A. speed, km h^{-1}
B. acceleration, m s^{-1}
C. power, W
D. momentum, kg m s^{-1}

12. **< HKCE 1987 Paper II - 7 >**

A mass of 3 kg initially at rest explodes into two fragments X and Y of masses 1 kg and 2 kg respectively. What is the ratio of the kinetic energy of X to that of Y just after the explosion ?

A. 1 : 4
B. 1 : 2
C. 2 : 1
D. 4 : 1

13. < HKCE 1987 Paper II - 2 >

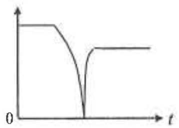
Which of the following is/are correct unit(s) for momentum ?

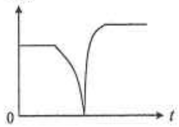
(1) kg m s^{-1}
(2) kg m s^{-2}
(3) N s

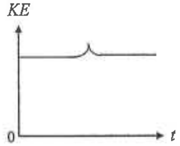
A. (1) only
B. (2) only
C. (1) & (3) only
D. (2) & (3) only

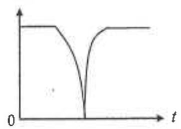
14. < HKCE 1987 Paper II - 1 >

A ball moving in a smooth horizontal plane hits against a wall and rebounds perfectly elastically. Which of the following graphs best represents the variation of kinetic energy with time ?

A.


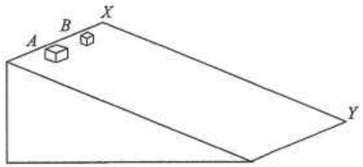
B.


C.


D.


15. < HKCE 1987 Paper II - 8 >

The figure shows a smooth plane on which two blocks *A* and *B* are released simultaneously from rest at *X* and slide down along the plane to *Y*. Block *A* is of mass 2*M* while block *B* is of mass *M*. On reaching *Y*, which of the following statements is/are correct ?

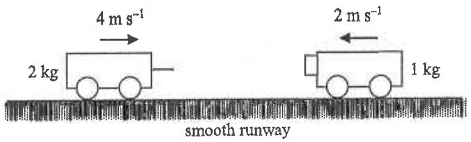


(1) The velocity of block *A* is double that of block *B*.
(2) The momentum of block *A* is double that of block *B*.
(3) The time taken by block *A* is double that of block *B*.

A. (1) only
B. (2) only
C. (1) & (3) only
D. (2) & (3) only

16. < HKCE 1988 Paper II - 2 >

The figure shows two trolleys moving towards each other along a smooth runway. After collision, they stick together. What is the total loss in kinetic energy by the trolleys during the collision ?



A. 3 J
B. 6 J
C. 9 J
D. 12 J

17. < HKCE 1989 Paper II - 4 >

Two metal spheres of unequal masses are released from rest at the same time from a height of 2 m above the ground. When they have fallen 1 m, (neglecting air resistance) they have the same

A. speed.
B. momentum.
C. weight.
D. kinetic energy.

18. < HKCE 1989 Paper II - 5 >

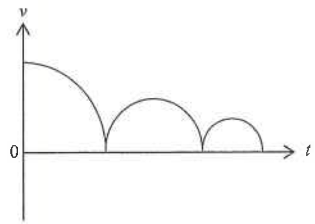
Bullets, each of mass *m*, are fired at the rate of *n* bullets per second. They hit a vertical wall with horizontal speed *v* and rebound from the wall with the same horizontal speed *v*. Which of the following statements is/are correct ?

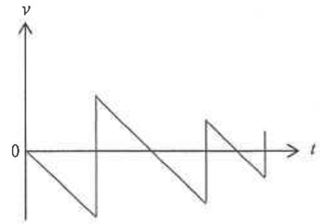
(1) The total change in momentum of the bullets is zero.
(2) The total change in momentum of the bullets in one second is 2 *m n v*.
(3) The average force exerted on the wall is 2 *m n v*.

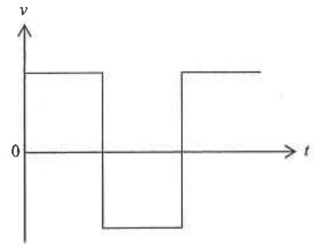
A. (1) only
B. (2) only
C. (1) & (3) only
D. (2) & (3) only

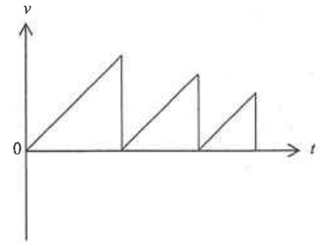
19. < HKCE 1990 Paper II - 8 >

A small metal ball is released from a point above the floor and bounces several times. Which of the following graphs best represents the variation of the velocity of the ball with time ?

A.


B.


C.


D.


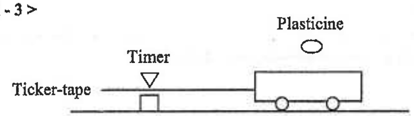
20. < HKCE 1990 Paper II - 7 >

Which of the following statements is/are correct when a collision between two particles is elastic ?

(1) None of the original kinetic energy is converted into other forms of energy.
(2) The linear momentum of each particle is conserved.
(3) The mechanical energy of each particle is conserved.

A. (1) only
B. (3) only
C. (1) & (2) only
D. (2) & (3) only

21. **< HKCE 1990 Paper II - 3 >**

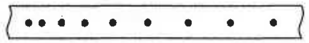


A trolley moves with constant speed along a horizontal surface. A lump of plasticine having the same mass as the trolley is dropped onto the trolley and sticks to it. Which one of the following ticker-tape best represents the motion of the trolley ?

A.


B.


C.


D.


22. **< HKCE 1991 Paper II - 11 >**

Two particles A and B of masses 2 kg and 1 kg respectively move in opposite directions. The initial velocity of A is 4 m s^{-1} towards the right, while that of B is 2 m s^{-1} towards the left. They collide head on. After the collision, the velocity of A becomes 1 m s^{-1} towards the right. What would be the velocity of particle B ?

A. 2 m s^{-1} towards the right
B. 3 m s^{-1} towards the right
C. 4 m s^{-1} towards the right
D. 6 m s^{-1} towards the right

23. **< HKCE 1991 Paper II - 8 >**

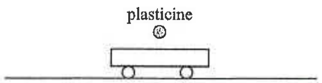
A ball collides with a fixed wall and bounces back with the same speed. Which of the following quantities of the ball remain(s) unchanged before and after the collision ?

(1) kinetic energy
(2) velocity
(3) momentum

A. (1) only
B. (2) only
C. (1) & (3) only
D. (2) & (3) only

24. **< HKCE 1992 Paper II - 5 >**

A trolley of mass 2 kg moves with a uniform speed of 4 m s^{-1} along a horizontal table. A lump of plasticine having the same mass as the trolley is dropped from a height slightly above the trolley and sticks to it. Find the total loss in kinetic energy.



A. 0 J
B. 4 J
C. 8 J
D. 12 J

25. **< HKCE 1993 Paper II - 1 >**

Which of the following pairs of physical quantities has/have the same unit ?

(1) Work and potential energy
(2) Power and momentum
(3) Specific heat capacity and specific latent heat of fusion

A. (1) only
B. (3) only
C. (1) & (2) only
D. (2) & (3) only

26. **< HKCE 1995 Paper II - 3 >**

A stone is thrown vertically upwards and it finally falls back to the starting point. Assume air resistance is negligible. Which of the following statements is/are true throughout the motion ?

(1) The acceleration of the stone is constant.
(2) The total mechanical energy of the stone is conserved.
(3) The momentum of the stone is conserved.

A. (1) only
B. (3) only
C. (1) & (2) only
D. (2) & (3) only

27. **< HKCE 1997 Paper II - 4 >**

Which of the following physical quantities is **not** a vector ?

A. Acceleration
B. Momentum
C. Weight
D. Work

28. **< HKCE 1997 Paper II - 5 >**

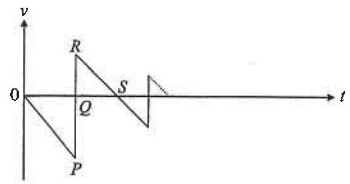
A particle of mass m is thrown vertically upwards with initial speed v. When the particle returns to its starting point, what are the changes in momentum and kinetic energy of the particle ?

	Change in momentum	Change in kinetic energy
A.	0	0
B.	0	$m v^2$
C.	$2 m v$	0
D.	$2 m v$	$m v^2$

29. **< HKCE 1998 Paper II - 5 >**

At time t = 0, a table-tennis ball is released from a point above the ground and bounces several times on the ground. The graph shows the variation of the velocity v of the ball with time t. At which of the following points on the graph does the ball reach its maximum height above the ground after the first rebound ?

(Note : Velocity pointing upwards is taken to be positive.)



A. Point P
B. Point Q
C. Point R
D. Point S

30. **< HKCE 1998 Paper II - 3 >**

A block is pulled by a constant force and moves along a smooth horizontal surface. Which of the following describes the variations of the acceleration and momentum of the block during the time when the force is acting ?

	Acceleration	Momentum
A.	remains unchanged	remains unchanged
B.	remains unchanged	increases
C.	increases	remains unchanged
D.	increases	increases

31. **< HKCE 1999 Paper II - 8 >**

A rocket is initially at rest in space. It then explodes and breaks into two parts which move in opposite directions. If the mass of the rear part is larger than that of the front part, which of the following statements is correct ?

A. The speeds of the two parts are equal.

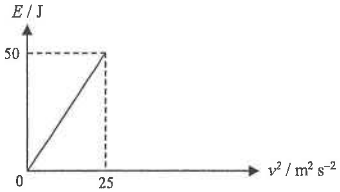
B. The speed of the rear part is higher than that of the front part.

C. The magnitudes of the momentum of the two parts are equal.

D. The magnitude of the momentum of the rear part is larger than that of the front part.

32. **< HKCE 2000 Paper II - 10 >**

The graph shows the variation of the kinetic energy E of an object with the square of its velocity v^2 moving on a straight line. What is the momentum of the object when it is moving at a velocity 4 m s^{-1} ?



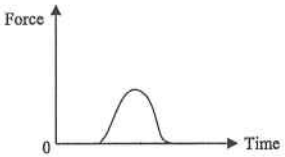
A. 4 kg m s^{-1}

B. 8 kg m s^{-1}

C. 16 kg m s^{-1}

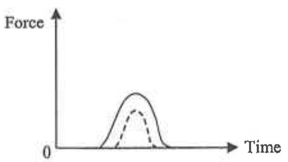
D. 32 kg m s^{-1}

33. **< HKCE 2001 Paper II - 8 >**

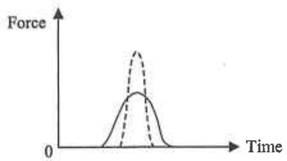


The figure above shows the variation of the force acting on a car driver with time when the car hits a wall. The driver is not wearing a seat-belt. Which of the following graphs (in dotted lines) best shows the force acting on the driver if he is wearing a seat-belt ?

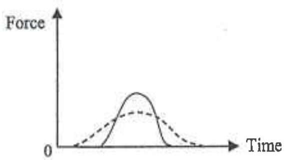
A.



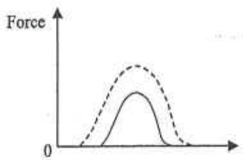
B.



C.



D.



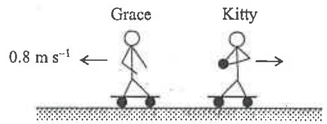
34. **< HKCE 2001 Paper II - 11 >**

A rocket of mass 5000 kg is at rest in space. It then explodes and breaks into two parts P_1 and P_2 of mass 1000 kg and 4000 kg respectively. Find the ratio of the kinetic energy of P_1 to P_2.

A. 1 : 16
B. 1 : 64
C. 4 : 1
D. 16 : 1

35. **< HKCE 2002 Paper II - 12 >**

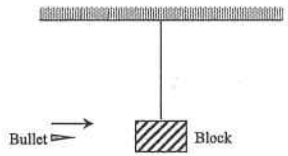
Grace and Kitty, of masses 50 kg and 40 kg respectively, stand on light rollers on a smooth horizontal floor. They are initially at rest with Grace holding a 2 kg ball. Grace throws the ball to Kitty and moves backward with a speed 0.8 m s^{-1} afterwards. After catching the ball, Kitty moves in the opposite direction as shown. Which of the following statements is/are correct ?



(1) The final speed of Kitty is 0.95 m s^{-1}.
(2) The horizontal momentum of the ball is conserved in this process.
(3) The total kinetic energy of Kitty and the ball decreases when Kitty catches the ball.

A. (2) only
B. (3) only
C. (1) & (2) only
D. (1) & (3) only

36. **< HKCE 2003 Paper II - 9 >**



A wooden block of mass M is hanging freely in the air from a light string of length L. A bullet, of mass m travelling at a speed v, hits the block and becomes embedded in it. The block then swings upwards. Which of the following are employed in determining the maximum height reached by the block ?

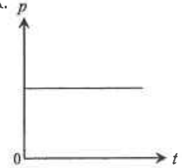
(1) Newton's first law
(2) Law of conservation of energy
(3) Law of conservation of momentum

A. (1) & (2) only
B. (1) & (3) only
C. (2) & (3) only
D. (1), (2) & (3)

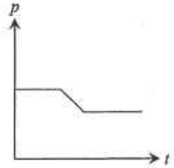
37. **< HKCE 2004 Paper II - 9 >**

A trolley moves along a smooth horizontal surface. A lump of plasticine is released from a height slightly above the trolley and sticks to it. Which of the following graphs shows the variation of the total horizontal momentum p of the trolley and plasticine with time t ?

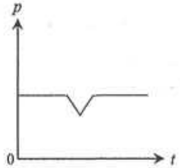
A.



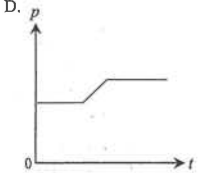
B.



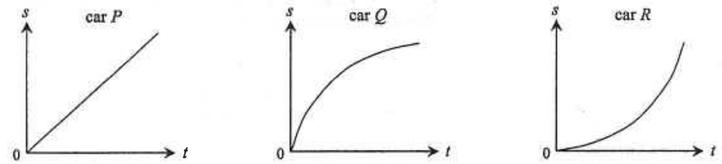
C.



D.



38. **< HKCE 2004 Paper II - 1 >**



Three cars P, Q and R move along a straight horizontal road. Their displacement-time graphs are shown above. Which of the cars experience a change in momentum during the motion ?

A. P and Q only
B. P and R only
C. Q and R only
D. P, Q and R

39. **< HKCE 2004 Paper II - 10 >**

The photograph shows an air-cushioned shoe. Which of the following statements about the air-cushion is/are correct ?

(1) It reduces the time of impact between the foot and the ground during running.
(2) It reduces the impact force acting on the foot during running.
(3) It reduces the friction between the shoe and the ground during running.

A. (1) only
B. (2) only
C. (1) & (3) only
D. (2) & (3) only

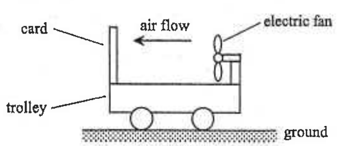
40. **< HKCE 2005 Paper II - 31 >**

A car P of mass 1000 kg moves with a speed of 20 m s^{-1} and makes a head-on collision with a car Q of mass 1500 kg, which was moving with a speed of 10 m s^{-1} in the opposite direction before the collision. If the two cars stick together after the collision, find their common velocity immediately after the collision.

A. 2 m s^{-1} along the original direction of P
B. 2 m s^{-1} along the original direction of Q
C. 14 m s^{-1} along the original direction of P
D. 14 m s^{-1} along the original direction of Q

41. **< HKCE 2006 Paper II - 6 >**

An electric fan is installed at one end of a trolley and a card is fixed at the other end with the plane of the card facing the fan. What happens to the trolley when the electric fan is turned on ?



A. The trolley remains stationary.
B. The trolley moves to the right.
C. The trolley moves to the left.
D. The trolley moves to and fro along the ground.

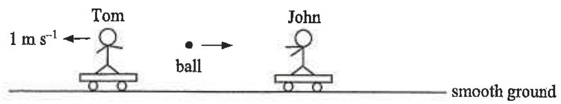
42. **< HKCE 2007 Paper II - 28 >**

A body initially at rest, is exploded into two parts. Which of the following correctly describes the change in total momentum and total kinetic energy ?

	Total momentum	Total kinetic energy
A.	increases	increases
B.	increases	remains unchanged
C.	remains unchanged	increases
D.	remains unchanged	remains unchanged

43. **< HKCE 2007 Paper II - 29 >**

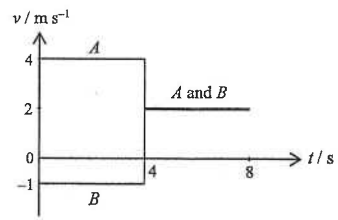
Tom and John stand on two trolleys of negligible masses. Both boys are initially at rest and Tom holds a ball of 3 kg. The masses of Tom and John are 30 kg and 27 kg respectively. After Tom has thrown the ball to John, Tom moves backwards with a speed of 1 m s^{-1}. What is the speed of John after he has caught the ball ?



A. 0.90 m s^{-1}
B. 1.00 m s^{-1}
C. 1.11 m s^{-1}
D. 1.22 m s^{-1}

44. **< HKCE 2008 Paper II - 31 >**

Trolleys A and B of masses m_A and m_B respectively travel along a horizontal road in opposite directions as shown.



Later they make a head-on inelastic collision and stick together. The graph below shows the velocity-time relationship of the two trolleys before and after the collision.

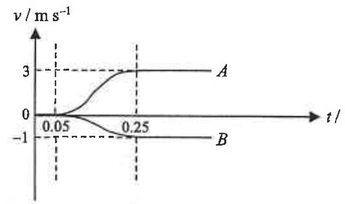
(Ignore the collision time and the friction acting on the trolleys.)

What is the ratio $m_A : m_B$?

A. 1 : 2
B. 2 : 3
C. 2 : 1
D. 3 : 2

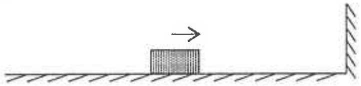
45. **< HKCE 2008 Paper II - 29 >**

In an explosion, an object is blown into 2 pieces, A and B, which fly off in opposite directions. The mass of A is 0.3 kg. The graph shows the variation of velocity of A and B with time before and after the explosion. What is the mass of B and the estimated magnitude of the average net force acting on B during the explosion ?

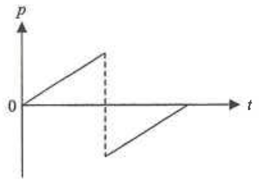


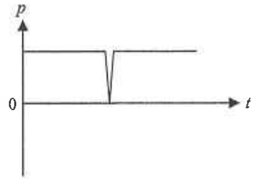
	Mass of B	Average net force acting on B
A.	0.1 kg	0.4 N
B.	0.1 kg	0.5 N
C.	0.9 kg	3.6 N
D.	0.9 kg	4.5 N

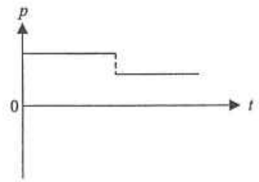
46. < HKCE 2009 Paper II - 30 >

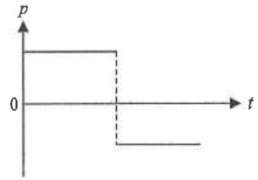


A block slides along a horizontal smooth surface as shown in the figure above. It collides with a vertical wall and rebounds along its original path. Which of the following graphs below best shows the variation of its momentum p with time t ?

A.


B.


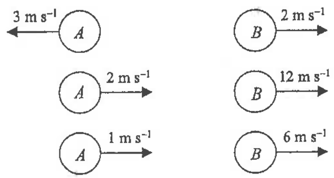
C.


D.


47. < HKCE 2010 Paper II - 32 >

Ball A and ball B of masses 2 kg and 1 kg respectively collide head-on as shown above. Which of the following diagrams show(s) the possible result(s) after the collision ?

(1)
(2)
(3)

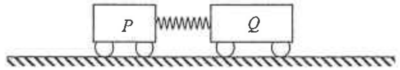


A. (1) only
B. (3) only
C. (1) & (2) only
D. (2) & (3) only

48. < HKCE 2011 Paper II - 33 >

An egg will probably break if it is released at a height and lands on a hard surface. However, the egg may not break if it is released at the same height but lands on a soft cushion. It is because, when the cushion is used,
A. the momentum of the egg just before impact becomes smaller.
B. the egg rebounds after hitting the cushion.
C. the rate of change of momentum of the egg becomes smaller during the impact.
D. the force acting on the egg by the cushion is smaller than the force acting on the cushion by the egg.

49. < HKCE 2011 Paper II - 32 >



On a horizontal smooth track, two trolleys P and Q are held at rest with a light compressed spring in between as shown in the above figure. The masses of P and Q are m and $2m$ respectively. When the trolleys are released and separate, trolley Q moves to the right with speed v. Which of the following statements are correct ?
(1) After separation, the total momentum of the two trolleys is 4 mv.
(2) After separation, the kinetic energy of trolley P is twice that of trolley Q.
(3) The energy initially stored in the compressed spring is at least 3 mv^2.
A. (1) & (2) only
B. (1) & (3) only
C. (2) & (3) only
D. (1), (2) & (3)

Part B : HKAL examination questions

50. < HKAL 1981 Paper I - 35 >

In a racing competition, the momentum of each competitor during the race is greater than that before he starts running. Which of the below statements is/are correct ?
(1) This situation violates the law of conservation of momentum.
(2) The law of conservation of momentum applies only to collisions between two objects.
(3) A force acts on each competitor to increase his momentum as he starts running.
A. (1) only
B. (3) only
C. (1) & (2) only
D. (2) & (3) only

51. < HKAL 1982 Paper I - 3 >

Two objects of masses m and $4m$ move towards each other along a straight line with kinetic energies K and $4K$ respectively. What is the total momentum of the two objects ?
A. $3\sqrt{2mK}$
B. $4\sqrt{2mK}$
C. $5\sqrt{2mK}$
D. $15\sqrt{2mK}$

52. < HKAL 1984 Paper I - 3 >

In the absence of external net force, if two bodies undergo an inelastic collision, then
A. kinetic energy and momentum are both conserved.
B. kinetic energy is not conserved but momentum is conserved.
C. kinetic energy is conserved but momentum is not conserved.
D. neither kinetic energy nor momentum is conserved.

53. < HKAL 1986 Paper I - 4 >

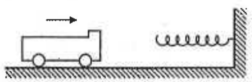
Ball X moving with velocity u on a smooth horizontal plane makes an elastic collision with ball Y initially at rest. If the two balls have the same mass, which of the following statements is/are correct ?
(1) Kinetic energy is conserved in the collision.
(2) Linear momentum is conserved in the collision.
(3) X and Y stick together and move off with the same velocity after the collision.
A. (1) only
B. (3) only
C. (1) & (2) only
D. (2) & (3) only

54. **< HKAL 1993 Paper I - 3 >**

A box moves at a uniform velocity of 2 m s^{-1} on a frictionless horizontal surface. Sand falls continuously into the box with negligible speed at a rate of 90 kg per minute. To keep the box moving uniformly at 2 m s^{-1}, the horizontal force needed is

A. 0 N
B. 3 N
C. 6 N
D. 90 N

55. **< HKAL 1995 Paper IIA - 3 >**



A trolley travels with constant velocity to the right on a smooth horizontal ground and collides with a light spring attached to a wall fixed to the ground (Earth) as shown in the figure. At the instant that the trolley comes momentarily to rest during collision, what has happened to the initial momentum of the trolley ?

A. The initial momentum has been transferred to the earth.
B. The initial momentum has been stored in the spring.
C. The initial momentum has changed into sound and heat.
D. The initial momentum has been destroyed by the friction due to the ground.

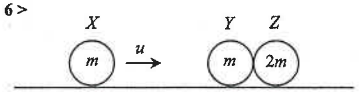
56. **< HKAL 1996 Paper IIA - 1 >**

Which of the following pairs of quantities of a moving object must be in the same direction ?

(1) acceleration and change in momentum
(2) displacement and instantaneous velocity
(3) instantaneous velocity and acceleration

A. (1) only
B. (3) only
C. (1) & (2) only
D. (2) & (3) only

57. **< HKAL 1996 Paper IIA - 6 >**



X, *Y* and *Z* are three balls with masses *m*, *m* and 2*m* respectively. They lie on a smooth horizontal surface with *Y* and *Z* in contact as shown. If now *X* is moving to the right with a velocity of *u* and it then makes a direct collision with *Y*, which of the following gives the possible velocities of the three balls after all collisions ? Assume all collisions are perfectly elastic. (Take the direction to the right as positive.)

	X	*Y*	*Z*
A.	0	0	$u/2$
B.	0	$u/3$	$u/3$
C.	$-u/3$	0	$2u/3$
D.	0	$-u/3$	$2u/3$

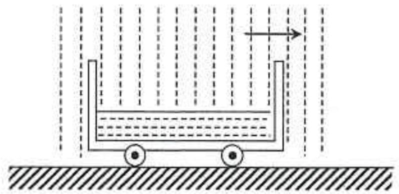
58. **< HKAL 1997 Paper IIA - 6 >**

A body initially at rest explodes into two parts of unequal mass. The part with smaller mass has a larger

(1) momentum.
(2) speed.
(3) kinetic energy.

A. (1) only
B. (3) only
C. (1) & (2) only
D. (2) & (3) only

59. **< HKAL 1999 Paper IIA - 3 >**

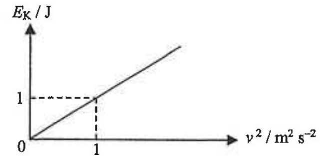


The figure shows an open trolley moving an initial speed on a smooth horizontal surface. Rain water falls continuously onto the trolley and accumulates there. What are the effects on the speed, horizontal momentum and kinetic energy of the trolley together with the rain ? (Ignore the initial kinetic energy of the rain water.)

	speed	**momentum**	**kinetic energy**
A.	decreased	unchanged	decreased
B.	decreased	unchanged	unchanged
C.	decreased	decreased	decreased
D.	unchanged	unchanged	unchanged

60. **< HKAL 1999 Paper IIA - 5 >**

The graph shows the variation of kinetic energy (E_K) with the square of velocity (v^2) of a moving ball of mass *m*. What is the momentum of the ball when it is moving at a speed of 2 m s^{-1} ?



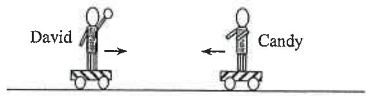
A. 1 N s
B. 2 N s
C. 4 N s
D. 8 N s

61. **< HKAL 2000 Paper IIA - 6 >**

Two bodies *X* and *Y* of masses *m* and 2*m* respectively are initially at rest on a smooth, horizontal surface. If a force of the same magnitude acts on each of them for the same period of time, the ratio of the kinetic energy of *X* to that of *Y* is

A. 2 : 1
B. 1 : 2
C. 1 : 1
D. 1 : 4

62. **< HKAL 2007 Paper IIA - 26 >**



David and Candy standing on light skateboards with frictionless rollers are moving towards each other as shown. Both of them have the same mass of 30 kg and move at a speed of 1.2 m s^{-1}. Initially David holds a ball of mass 1.0 kg. He then throws the ball straight towards Candy at a horizontal velocity of 15 m s^{-1}. Determine the velocity of Candy after she catches the ball.

A. 0.74 m s^{-1} to the right
B. 0.74 m s^{-1} to the left
C. 0.68 m s^{-1} to the right
D. 0.68 m s^{-1} to the left

Part C : Supplemental exercise

63. Which of the following statements concerning the design of cars is/are correct ?

(1) The front and rear parts of cars are designed to collapse during a serious traffic accident.

(2) The collapsible parts can reduce the time of collision when the car is involved in a serious accident.

(3) The collapsible parts can reduce the change of momentum in a serious accident.

A. (1) only
B. (2) only
C. (1) & (3) only
D. (2) & (3) only

64. Which of the following statements concerning the air-cushioned sports shoes is/are correct ?

(1) Air-cushioned sports shoes can increase the time of impact between the feet and the ground during running.

(2) Air-cushioned sports shoes can reduce the change of momentum during jumping and running.

(3) Air-cushioned sports shoes can reduce the impact force acting on the feet during jumping and running.

A. (1) only
B. (2) only
C. (1) & (3) only
D. (2) & (3) only

65. When a lorry makes a head-on collision with a motor-cycle, which of the following statements is/are correct ?

(1) The magnitude of the average force exerted by the lorry on the motorcycle is equal to that exerted by the motorcycle on the lorry.

(2) The magnitude of the change in momentum of the lorry is equal to that of the motorcycle.

(3) The magnitude of the change in velocity of the lorry is equal to that of the motorcycle.

A. (1) only
B. (3) only
C. (1) & (2) only
D. (2) & (3) only

66. Which of the following concerning the wearing of seat-belts is/are correct ?

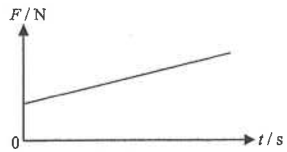
(1) Wearing seat-belts can reduce the change in momentum of passengers in a car during a collision.

(2) Wearing seat-belts can reduce the force acting on passengers in a car during a collision.

(3) Wearing seat-belts can prevent the passengers from jerking forwards when the car is suddenly stopped.

A. (1) only
B. (3) only
C. (1) & (2) only
D. (2) & (3) only

67. The graph shows the variation with the time t of the resultant force F acting on a body moving along a straight line. The shaded area represents



A. the momentum of the body.

B. the change in momentum of the body.

C. the change in the velocity of the body.

D. the change in the kinetic energy of the body.

68.

Ball A moving with speed u collides head-on with another ball B which is initially at rest on a smooth horizontal surface. After collision, A and B move together with a common velocity v.
Which of the following statements concerning the two balls during the collision is/are correct ?

(1) The change of momentum of ball A is equal in magnitude to that of ball B.
(2) The loss of kinetic energy of ball A is equal to the gain of kinetic energy of ball B.
(3) The final velocity v is halved of the initial velocity u.

A. (1) only
B. (2) only
C. (1) & (3) only
D. (2) & (3) only

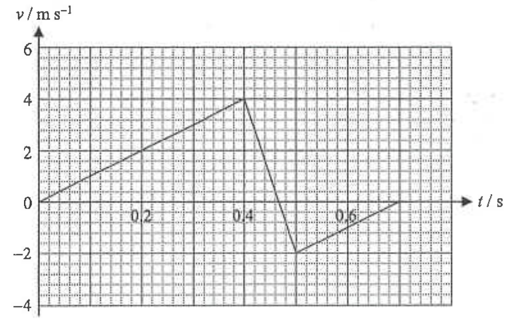
Part D : HKDSE examination questions

69. **< HKDSE Sample Paper IA - 13 >**

A car P of mass 1000 kg moves with a speed of 20 m s^{-1} and makes a head-on collision with a car Q of mass 1500 kg, which was moving with a speed of 10 m s^{-1} in the opposite direction before the collision. If the two cars stick together after the collision, find their common velocity immediately after the collision.

A. 2 m s^{-1} along the original direction of P
B. 2 m s^{-1} along the original direction of Q
C. 14 m s^{-1} along the original direction of P
D. 14 m s^{-1} along the original direction of Q

70. **< HKDSE Practice Paper IA - 13 >**



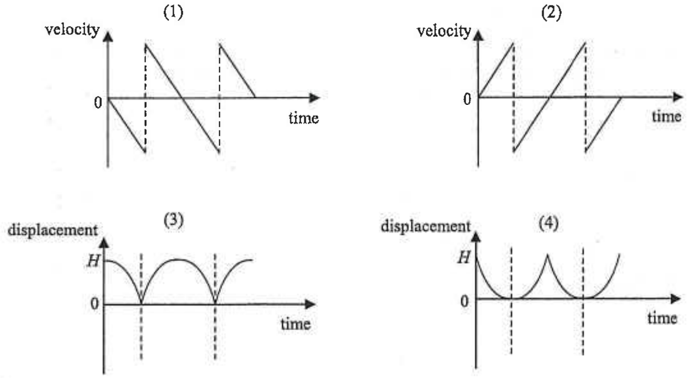
A ball of mass 0.2 kg is released from rest. It hits the ground and rebounds. The velocity-time graph of the ball is shown above. Which of the following statements are correct ?

(1) The magnitude of the change in momentum of the ball during the collision is 1.2 kg m s^{-1}.
(2) The magnitude of the average force acting on the ball by the ground during the collision is 12 N.
(3) There is mechanical energy loss during the collision.

A. (1) & (2) only
B. (1) & (3) only
C. (2) & (3) only
D. (1), (2) & (3)

71. < HKDSE 2012 Paper IA - 7 >

Which of the following graphs (velocity-time and displacement-time) best represent the motion of a ball falling from rest under gravity at a height H and bouncing back from the ground two times ? Assume that the collision with the ground is perfectly elastic and neglect air resistance. (Downward measurement is taken to be negative.)



A. (1) and (3) only
B. (1) and (4) only
C. (2) and (3) only
D. (2) and (4) only

72. < HKDSE 2013 Paper IA - 10 >

Two identical spheres are moving in opposite directions with speeds u and v (with $u > v$) respectively as shown. They make a head-on collision. Which of the following diagrams show(s) a *possible* situation of the spheres after collision ?

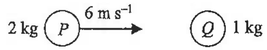
(1)


(2)


(3)


A. (1) only
B. (3) only
C. (1) & (2) only
D. (2) & (3) only

73. < HKDSE 2014 Paper IA - 7 >

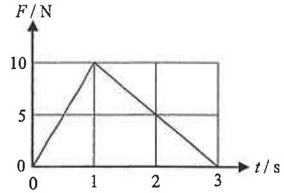


A sphere P of mass 2 kg makes a head-on collision with another sphere Q of mass 1 kg which is initially at rest. The speed of P just before collision is 6 m s^{-1}. If the two spheres move in the same direction after collision, which of the following could be the speed(s) of Q just after collision ?

(1) 2 m s^{-1}
(2) 4 m s^{-1}
(3) 6 m s^{-1}

A. (1) only
B. (1) & (2) only
C. (2) & (3) only
D. (1), (2) & (3)

74. < HKDSE 2015 Paper IA - 6 >

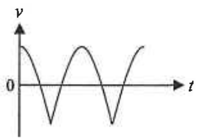


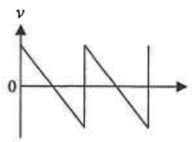
An object of mass 3 kg is initially at rest on a smooth horizontal ground. A force F is applied horizontally to the object such that the magnitude F varies with time t as shown. What is the speed of the object at t = 3 s ? Neglect air resistance.

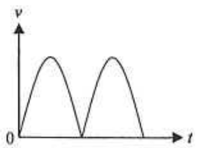
A. 2.5 m s^{-1}
B. 5.0 m s^{-1}
C. 10 m s^{-1}
D. 15 m s^{-1}

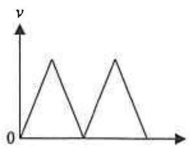
75. < HKDSE 2015 Paper IA - 7 >

A rubber ball bounces vertically up and down from the ground. Which graph best shows the variation of its velocity v with time t if the collisions are elastic ? Neglect air resistance.

A.


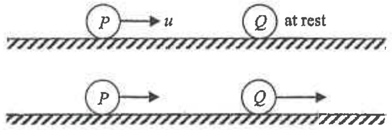
B.


C.


D.


76. < HKDSE 2016 Paper IA - 12 >

On a smooth horizontal surface, a marble P moving with speed u collides head-on with another marble Q, which is at rest. After collision, P and Q move with different speeds as shown.



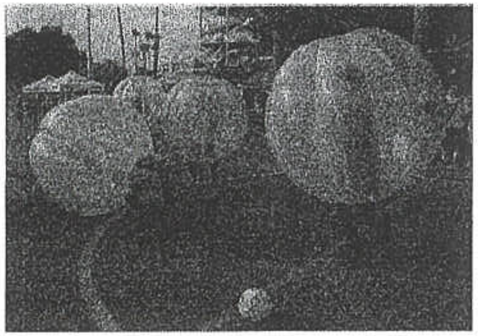
Which of the following statements about this collision is/are correct ?

(1) During collision, the force acting on Q by P is equal and opposite to that acting on P by Q.
(2) The total momentum of the two marbles is conserved only when the collision is perfectly elastic.
(3) The kinetic energy lost by P must be equal to that gained by Q.

A. (1) only
B. (2) only
C. (1) & (3) only
D. (2) & (3) only

77. < HKDSE 2017 Paper IA - 12 >

Players of "bubble soccer" wear air-filled plastic "bubbles" as shown.



Which of the following statements best explains why the bubble can reduce the chance of injury during a collision ?

A. The bubble increases the mass of the player, thus the momentum of the player increases.
B. The bubble increases the air resistance acting on the player.
C. The bubble lengthens the impact time during a collision.
D. Like a balloon, the bubble provides a lifting force to the player.

HKEAA's Marking Scheme is prepared for the markers' reference. It should not be regarded as a set of model answers. Students and teachers who are not involved in the marking process are advised to interpret the Marking Scheme with care.

M.C. Answers

1. D	11. D	21. B	31. C	41. A
2. B	12. C	22. C	32. C	42. C
3. C	13. C	23. A	33. C	43. B
4. A	14. D	24. C	34. C	44. D
5. D	15. B	25. A	35. D	45. D
6. A	16. D	26. C	36. C	46. D
7. D	17. A	27. D	37. A	47. B
8. D	18. D	28. C	38. C	48. C
9. D	19. B	29. D	39. B	49. C
10. D	20. A	30. B	40. A	50. B

51. A	61. A	71. A
52. B	62. D	72. D
53. C	63. A	73. C
54. B	64. C	74. B
55. A	65. C	75. B
56. A	66. D	76. A
57. C	67. B	77. C
58. D	68. A	78. A
59. A	69. A	79. B
60. C	70. B	80. C

M.C. Solution

1. D

× (1) Constant net force ⇒ constant acceleration (by Newton's Second Law)
✓ (2) Constant acceleration ⇒ varying velocity ⇒ varying momentum ($m\,v$)
✓ (3) Constant acceleration ⇒ varying velocity ⇒ varying KE ($\frac{1}{2}mv^2$)

2. B

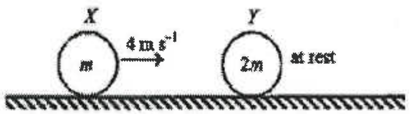
After the second impact : $KE_2 = \frac{1}{2} \times \frac{1}{2} \times KE_o = \frac{1}{4} KE_o$

At the topmost point, loss of KE = gain in PE ∴ PE reduced to $\frac{1}{4}$ of its original value

As $PE = mgh$ ∴ $PE \propto h$ ∴ The ball will rise above the ground by $\frac{1}{4}h$.

78. <HKDSE 2019 Paper IA-10>

79. <HKDSE 2019 Paper IA-11>



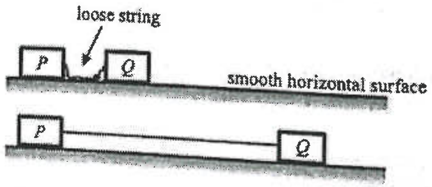
On a smooth horizontal surface, sphere X of mass m travels with speed 4 m s^{-1}. It collides head-on with another sphere Y of mass $2m$, which is at rest initially. Which of the following can be the speed of Y just after collision ?

(1) 1 m s^{-1} (2) 2 m s^{-1} (3) 3 m s^{-1}

A. (1) only
B. (2) only
C. (1) and (2) only
D. (2) and (3) only

80. <HKDSE 2020 Paper IA-8>

On a smooth horizontal surface, two identical blocks P and Q are connected by a light inextensible string. The blocks are at rest and the string is loose initially.



Q is given a speed of 4 m s^{-1} and moves to the right. Find the speeds of the blocks when the string just becomes taut and P starts to move.

	block P	block Q
A.	1 m s^{-1}	1 m s^{-1}
B.	2 m s^{-1}	1 m s^{-1}
C.	2 m s^{-1}	2 m s^{-1}
D.	4 m s^{-1}	2 m s^{-1}

3. C

$KE = \frac{1}{2}mv^2 = \frac{(mv)^2}{2m} \propto \frac{1}{m}$

Loss of KE = work done against the resistive force

$\therefore KE = Fs$ $\therefore KE \propto s$

$\therefore s \propto \frac{1}{m}$

$\therefore \frac{s_P}{s_Q} = \frac{m_Q}{m_P} = \frac{3}{2}$

4. A

✓ (1) Same speed before and after collision.
By $KE = \frac{1}{2}mv^2$, thus same KE before and after collision

× (2) Same speed after collision but direction changes, as velocity is a vector, it changes after collision.

× (3) Momentum is also a vector.

5. D

No external net force acting on the system, thus, total momentum of the system is conserved

Total momentum = $(m\,v) + (-m\,v) = 0$

6. A

$m_1 u_1 + m_2 u_2 = m_1 v_1 + m_2 v_2$

$\therefore (1)(2) + (2)(0) = (1+2)\,v$

$\therefore v = 0.67\ \text{m s}^{-1}$

7. D

× (1) Constant net force ⇒ constant acceleration (by Newton's Second Law)

✓ (2) Constant acceleration ⇒ increasing velocity ⇒ increasing momentum ($m\,v$)

✓ (3) Constant acceleration ⇒ increasing velocity ⇒ increasing KE ($\frac{1}{2}m\,v^2$)

8. D

✓ (1) $PE = m\,g\,h$ $\therefore PE \propto h$
Rises by $\frac{1}{4}$ of its original height ⇒ it has $\frac{1}{4}$ of its original PE at topmost point.
As loss of KE = gain in PE
$\therefore$ KE at the lowest point has $\frac{1}{4}$ of its original value after collision.

× (2) Same level at these 2 instants ⇒ same PE just before and just after collision

✓ (3) By $KE = \frac{1}{2}mv^2 \propto v^2$, the speed just before collision is double that just after collision.

9. D

$v^2 = u^2 + 2\,a\,s$ $\therefore v^2 = (0) + 2\,(10)(5)$ $\therefore v = 10\ \text{m s}^{-1}$

The force acting on the ball by the ground during impact is the normal reaction force R.

$R - m\,g = \frac{m\,v - m\,u}{t}$

$R - (2)(10) = \frac{(2)(10) - (2)(-10)}{0.2}$ $\therefore R = 220\ \text{N}$

10. D

I : Area of speed-time graph represents displacement or distance

II : Area of force-distance graph represents work or energy

11. D

			Vector		Unit
×	A.	×	Speed : scalar	✓	km h^{-1} : unit of speed.
×	B.	✓	Acceleration : vector	×	m s^{-2} is the correct unit of acceleration.
×	C.	×	Power : scalar	✓	W : unit of power.
✓	D.	✓	Momentum : vector	✓	kg m s^{-1} : unit of momentum.

12. C

Explosion without external net force ⇒ their momentum are equal and opposite

$KE = \frac{1}{2}mv^2 = \frac{(mv)^2}{2m} \propto \frac{1}{m}$ $\therefore \frac{KE_X}{KE_Y} = \frac{m_Y}{m_X} = 2$

13. C

✓ (1) momentum = mv = (kg)(m s^{-1}) = kg m s^{-1}

× (2) It is a unit of force.

✓ (3) kg m s^{-1} = (kg m s^{-2})(s) = N s

14. D

As the ball rebounds perfectly elastically, there is no loss in KE, thus same KE before and after collision.

When the ball comes to rest at an instant, the KE is zero.

$\therefore$ D is the most suitable one.

15. B

× (1) Since the two blocks have the same acceleration : $g \sin\theta$, they must have the same final velocity

✓ (2) Momentum = mv. As mass of A is double with the same final velocity, thus momentum of A is double.

× (3) As both blocks have the same acceleration, they take the same time to reach the bottom Y.

16. D

$m_1 u_1 + m_2 u_2 = (m_1 + m_2) v$

$\therefore$ $(2)(4) + (1)(-2) = (2+1) v$ $\therefore$ $v = 2 \text{ m s}^{-1}$

$\Delta KE = \frac{1}{2} m_1 u_1^2 + \frac{1}{2} m_2 u_2^2 - \frac{1}{2}(m_1 + m_2) v^2 = \frac{1}{2}(2)(4)^2 + \frac{1}{2}(1)(2)^2 - \frac{1}{2}(2+1)(2)^2 = 12 \text{ J}$

17. A

✓ A. Both spheres have same acceleration due to gravity and same distance travelled, thus same speed

× B. Both spheres have the same velocity but different mass, thus different momentum

× C. Both spheres have the same acceleration due to gravity but different mass, thus different weight

× D. Both spheres have the same speed but different mass, thus different kinetic energy.

18. D

× (1) Change in momentum of one bullet $= m v - (-m v) = 2 m v$

✓ (2) Total change in momentum of n bullets in one second $= n \times [m v - (-m v)] = 2 m n v$

✓ (3) Average force = total change of momentum of n bullets in one second $= 2 m n v$

19. B

Take upward direction as positive

Initially the velocity is zero since it is released from rest.

It then falls downwards with uniform acceleration due to gravity, thus v is (–) and is a straight line with (–) slope
During collision with the ground, the velocity changes from (–) to (+) in a very short time, thus give a vertical line.

20. A

✓ (1) As the collision is elastic, total KE is conserved, i.e. the final KE would equal the initial KE, thus no KE is lost and converted to other forms of energy.

× (2) The total momentum of the two particles is conserved, however, the momentum of one particle is not conserved, due to the impact force on the particle.

× (3) The total KE of the two particles is conserved, however, the KE of one particle is not conserved, as during the collision, there is transfer of KE from one particle to another particle.

21. B

After a plasticine has stuck on it, as momentum is conserved : $m v$ = constant

The increase of mass causes the decrease of velocity $\therefore$ separation of dots decreases

22. C

Take rightward direction as positive,

$m_A u_A + m_B u_B = m_A v_A + m_B v_B$

$(2)(4) + (1)(-2) = (2)(1) + (1) v_B$ $\therefore$ $v_B = 4 \text{ m s}^{-1}$

23. A

✓ (1) By $KE = \frac{1}{2} m v^2$, same speed indicates same KE before and after collision

× (2) Same speed after collision but direction changes, thus velocity changes since it is a vector

× (3) As the direction has changed after collision, momentum has changed as momentum is also a vector.

24. C

$m_1 u_1 + m_2 u_2 = (m_1 + m_2) v$

$(2)(4) + (2)(0) = (2+2) v$

$\therefore$ $v = 2 \text{ m s}^{-1}$

$\Delta KE = \frac{1}{2} m_1 u_1^2 + \frac{1}{2} m_2 u_2^2 - \frac{1}{2}(m_1 + m_2) v^2 = \frac{1}{2}(2)(4)^2 - \frac{1}{2}(2+2)(2)^2 = 8 \text{ J}$

25. A

✓ (1) Both of them have the same unit : J

× (2) Unit of power : W = N m s^{-1} ; Unit of momentum : N s

× (3) Unit of specific heat capacity : J kg^{-1} °C^{-1}; Unit of specific latent heat of fusion : J kg^{-1}.

26. C

✓ (1) The acceleration is constant due to the same acceleration due to gravity g.

✓ (2) As no work is done on the stone and no air resistance, total mechanical energy ($KE + PE$) is conserved.

× (3) As there is an external force, the weight, acting on the stone, its momentum would not conserve.

27. D

✓ A. Acceleration is a vector.

✓ B. Momentum is a vector.

✓ C. Weight, a kind of force, is a vector.

× D. Work, a process to transfer energy, is a scalar.

28. C

① When it returns to the starting point, it has the same speed but in opposite direction, thus the change in momentum $= m v - (-m v) = 2 m v$

② When it returns to the starting point, it has the same speed and thus the same KE, change in KE is thus zero.

29. D

From O to P, the ball falls to the ground with acceleration under the acceleration due to gravity g.

At P, the ball just reaches the ground.

At Q, the ball has maximum compression and still at the ground.

At R, the ball restores its original shape and just leaves the ground.

From R to S, the ball moves upwards and decelerates under the acceleration due to gravity g.

At S, the ball reaches the maximum height

30. B

Acceleration : Constant force gives constant acceleration

Momentum : As the block accelerates, its velocity increases, thus the momentum ($m\ v$) also increases,

31. C

× A. By mv = constant , $m \propto \frac{1}{v}$. different masses have different speeds

× B. By mv = constant , $m \propto \frac{1}{v}$. $m_r > m_f$ ∴ $v_r < v_f$

✓ C. Upon explosion, no external force acts the system.

× D. By $m_1v_1 + m_2v_2 = 0$, both parts have the same magnitude of momentum.

32. C

$KE = \frac{1}{2} m v^2$

When KE = 50 J, v^2 = 25 $m^2\ s^{-2}$

∴ $(50) = \frac{1}{2} m (25)$

∴ m = 4 kg

∴ momentum of the object at a velocity of 4 m s^{-1} = $m\ v$ = 4 × 4 = 16 kg m s^{-1}

33. C

Wearing a seat-belt can increase the duration time of impact and thus reduce the impact force

34. C

As $KE = \frac{1}{2} m v^2 = \frac{(mv)^2}{m} \propto \frac{1}{m}$

KE of P_1 : KE of P_2 = mass of P_2 : mass of P_1 = 4000 : 1000 = 4 : 1

35. D

✓ (1) By conservation of momentum, (50+2)(0) + (40)(0) = (50)(−0.8) + (40+2)v_2 ∴ v_2 = 0.95 m s^{-1}

× (2) Total momentum of the system is conserved but the horizontal momentum of the ball is not conserved due to external force acting on the ball by Grace and later by Kitty

✓ (3) When Kitty catches the ball, it is an inelastic collision, thus total kinetic energy must decrease.

36. C

× (1) Newton's first law describes the inertia of a body that would not be used in calculation

✓ (2) The law of conservation of energy is used during the motion when the block swings upwards.

✓ (3) The law of conservation of momentum is used when the bullet hits the block.

37. A

Since there is no external force, the total horizontal momentum p of the trolley and the plasticine is conserved.

Thus the graph should be a horizontal straight line.

38. C

Car P has constant velocity and thus no change in momentum since the slope of s-t graph is constant.

Car Q has decreasing velocity and thus decrease in momentum since the slope of s-t graph is decreasing.

Car R has increasing velocity and thus increase in momentum since the slope of s-t graph is increasing.

39. B

× (1) Air-cushion increases the time of impact.

✓ (2) Air-cushion reduces the impact force since $F = (m\ v - m\ u) / t$

× (3) Friction should be related to the roughness of the bottom of the shoe, but not the air-cushion.

40. A

By $m_1 u_1 + m_2 u_2 = m_1 v_1 + m_2 v_2$

∴ (1000)(+20) + (1500)(−10) = (1000 + 1500) v

∴ v = +2 m s^{-1}

Their common velocity is along the positive direction, i.e. the original direction of P.

41. A

Since the air flow is stopped by the card, no air moves out towards the left.

By Conservation of momentum,

the trolley remains at rest, i.e. stationary.

42. C

Since there is no external force acting on the body, the total momentum of the two parts is conserved and is unchanged.

When they are at rest, the total kinetic energy is zero.

After explosion, the two parts move off from each other.

These two parts gain kinetic energy.

43. B

The total momentum of Tom, John and the ball is zero initially.

By Conservation of momentum : 0 = (30) (−1) + (27 + 3) v ∴ v = 1 m s^{-1}

< OR >

Consider Tom and the ball : 0 = (30) (−1) + (3) v_b ∴ v_b = 10 m s^{-1}

Consider the ball and John : (3) (10) = (3 + 27) v ∴ v = 1 m s^{-1}

44. D

From the graph, the initial velocity of A is + 4 m s^{-1} and that of B is −1 m s^{-1}.

By the Law of conservation of momentum :

$m_A u_A + m_B u_B = (m_A + m_B) v$

$m_A (4) + m_B (-1) = (m_A + m_B)(2)$

$\therefore\ 2 m_A = 3 m_B \qquad \therefore\ \dfrac{m_A}{m_B} = \dfrac{3}{2}$

45. D

① By Conservation of momentum : $m_A u_A + m_B u_B = m_A v_A + m_B v_B$

$(0) + (0) = (0.3)(3) + m_B(-1) \qquad \therefore\ m_B = 0.9$ kg

② By $F_B = \dfrac{mv - mu}{t} = \dfrac{(0.9)(-1) - 0}{(0.25 - 0.05)} = -4.5$ N

$\therefore$ Magnitude of average net force on B = 4.5 N

46. D

Before collision, the momentum is unchanged and is positive, with direction towards the right.

After collision, the momentum becomes negative, with direction towards the left.

47. B

Check that whether the total momentum before and after collision is conserved or not.

Take the rightward direction as positive.

× (1) $(2)(6) + (1)(-4) \neq (2)(-3) + (1)(2)$

× (2) $(2)(6) + (1)(-4) \neq (2)(2) + (1)(12)$

✓ (3) $(2)(6) + (1)(-4) = (2)(1) + (1)(6)$

48. C

The cushion is soft, thus it can increase the duration time of impact,

thus the rate of change of momentum becomes smaller,

therefore, the impact force is also smaller.

49. C

× (1) After separation, the total momentum is conserved and is equal to zero.

✓ (2) After separation, by conservation of momentum : $(m) v_P = (2m)(v) \qquad \therefore\ v_P = 2v$

Ratio of KE of trolley P to Q = $\frac{1}{2}(m)(2v)^2 : \frac{1}{2}(2m)(v)^2 = 2 : 1$

✓ (3) Total KE of the two trolleys after separation = $\frac{1}{2}(m)(2v)^2 + \frac{1}{2}(2m)(v)^2 = 3\,m\,v^2$

Some energy may be lost in the separation, thus the initial energy stored in the spring is at least $3\,m\,v^2$.

50. B

× (1) The momentum change is due to the friction which is an external force acting on the competitor.
The Law of conservation of momentum has not been violated
as it has stated that momentum would only conserve under no external net force.

× (2) Conservation of momentum can be applied to all types of motion with no external force acting.

✓ (3) Force (friction) acting on the competitor by the ground increases the momentum of competitor.

51. A

For mass m : $K = \dfrac{1}{2} \cdot \dfrac{(mv)^2}{m}$ $\qquad \therefore$ momentum of the mass m = $m\,v = \sqrt{2mK}$

For mass $4m$: $4K = \dfrac{1}{2} \cdot \dfrac{(4mv)^2}{4m}$ $\qquad \therefore$ momentum of the mass $4m$ = $4m\,v = 4\sqrt{2mK}$

As m and $4m$ moves in opposite direction,

$\therefore$ total momentum of the two bodies = $(4\sqrt{2mK}) + (-\sqrt{2mK}) = 3\sqrt{2mK}$

52. B

Absence of external forces ⇒ momentum is conserved

Inelastic collision ⇒ KE is not conserved

53. C

✓ (1) Elastic collision ⇒ KE is conserved

✓ (2) No external net force ⇒ Linear momentum is conserved

× (3) Stick together will only occur for an inelastic collision

54. B

$F = \dfrac{mv - mu}{t} = \dfrac{m}{t}(v - u) = \dfrac{90}{60}(2 - 0) = 3$ N

55. A

As the trolley makes collision with the earth, there is no external force acting on the system of trolley and the earth

$\therefore$ total momentum of the trolley and the earth is conserved

$\therefore$ momentum of trolley is transferred to the earth.

56. A

✓ (1) Acceleration : same direction as force ; Force : same direction as change of momentum

× (2) Counter example : Moving backward to starting point at the left ⇒ rightward s and leftward v

× (3) Counter example : Throwing an object upward ⇒ upward v and downward a

57. C

Initial momentum = mu — Initial energy = $\frac{1}{2}mu^2$

Conservation of momentum (No external force ⇒ momentum is conserved)

Conservation of kinetic energy (Perfectly elastic collision ⇒ KE is conserved)

× A. $m(0)+m(0)+2m\left(\frac{u}{2}\right)=mu$ ✓ $\frac{1}{2}m(0)^2+\frac{1}{2}m(0)^2+\frac{1}{2}\cdot 2m\left(\frac{u}{2}\right)^2=\frac{mu^2}{4}$ ×

× B. $m(0)+m\left(\frac{u}{3}\right)+2m\left(\frac{u}{3}\right)=mu$ ✓ $\frac{1}{2}m(0)^2+\frac{1}{2}m\left(\frac{u}{3}\right)^2+\frac{1}{2}\cdot 2m\left(\frac{u}{3}\right)^2=\frac{mu^2}{6}$ ×

✓ C. $m\left(\frac{-u}{3}\right)+m(0)+2m\left(\frac{2u}{3}\right)=mu$ ✓ $\frac{1}{2}m\left(\frac{-u}{3}\right)^2+\frac{1}{2}m(0)^2+\frac{1}{2}\cdot 2m\left(\frac{2u}{3}\right)^2=\frac{mu^2}{2}$ ✓

× D. $m(0)+m\left(\frac{-u}{3}\right)+m\left(\frac{2u}{3}\right)=mu$ ✓ $\frac{1}{2}m(0)^2+\frac{1}{2}m\left(\frac{-u}{3}\right)^2+\frac{1}{2}\cdot 2m\left(\frac{2u}{3}\right)^2=\frac{mu^2}{2}$ ✓

After all collisions, X is at rest and Y moves to the left and Z moves to the right.
That means, Y would move towards X and would hit X again, thus it is NOT reasonable.

58. D

× (1) Explosion ⇒ $0=m_Av_A+m_Bv_B$ ⇒ Magnitude of momentum $p_A=p_B$

✓ (2) By $mv=\text{constant}$, smaller mass ⇒ larger speed

✓ (3) By $KE=\frac{1}{2}mv^2=\frac{(mv)^2}{2m}\propto\frac{1}{m}$ ∴ smaller mass ⇒ larger kinetic energy

59. A

Speed : By the law of conservation of momentum, $m\uparrow\Rightarrow v\downarrow$

Momentum : Since there is no horizontal external net force acts on the trolley, its momentum must be conserved.

Kinetic energy : Since the collision is inelastic, the total kinetic energy must decrease.

60. C

As kinetic energy $E_K=\frac{1}{2}mv^2$

∴ $(1)=\frac{1}{2}m(1)^2$

∴ $m=2$ kg

∴ Momentum of the ball moving at 2 m s^{-1} = (2) × (2) = 4 N s

61. A

As $Ft=mv-mu=mv$ as $u=0$

∴ Same applied force F for the same period of time t ⇒ same momentum mv

$KE=\frac{1}{2}mv^2=\frac{(mv)^2}{2m}\propto\frac{1}{m}$ ∴ $\frac{KE_X}{KE_Y}=\frac{m_Y}{m_X}=\frac{2m}{m}=2$

62. D

The total momentum of the ball and Candy is conserved and the collision is inelastic as Candy catches the ball.

By $m_1u_1+m_2u_2=(m_1+m_2)v$

∴ (1)(15) + (30)(−1.2) = (1 + 30) v ∴ v = − 0.68 m s^{-1}

Candy should move to the left with speed of 0.68 m s^{-1}.

63. A

✓ (1) These parts are collapsible so that the duration time of impact can be increased.

× (2) The time of collision should be increased, not reduced.

× (3) Even with the collapsible parts, the final momentum is zero when the car stops.
Thus, the change of momentum should be the same.

64. C

✓ (1) Air-cushion can increase the time of impact due to the elastic nature.

× (2) The change of momentum should be the same even with the air-cushion.

✓ (3) As the time of impact is increased, the impact force is reduced, by $F=(mv-mu)/t$.

65. C

✓ (1) These two forces are action and reaction, thus they must be equal and opposite.

✓ (2) By $F=(mv-mu)/t$, as the forces are equal,
the change of momentum $(mv-mu)$ must also be equal in magnitude.

× (3) As their masses are not equal, their change of velocity $(v-u)$ must not be equal.

66. D

× (1) As the passengers would finally come to rest, the change of momentum is the same
even if they wear seat-belts.

✓ (2) As the seat-belts are elastic, they can increase the time of impact, thus reduce the impact force.

✓ (3) Due to inertia, the passengers would jerk forwards when the car is suddenly stopped.
Wearing seat-belts can prevent the passenger from throwing forwards.

67. B

Since $Ft=mv-mu$.

The area of $F-t$ graph represents the change of momentum of a body

68. A

✓ (1) Since the total momentum of the two balls is conserved no matter the collision is elastic or not,
thus the decrease of momentum of A must be equal to the increase of momentum of B.

× (2) Since the collision is inelastic, total kinetic energy of the two balls is not conserved.
Thus, the loss of $K.E.$ of A is not equal to the gain of $K.E.$ of B, as some $K.E.$ changes to internal energy.

× (3) By $m_Au=(m_A+m_B)v$
Since the mass of the two balls may not be equal, v may not be equal to $\frac{1}{2}u$.

69. A

By $m_1 u_1 + m_2 u_2 = m_1 v_1 + m_2 v_2$

$\therefore$ (1000)(+20) + (1500)(−10) = (1000 + 1500) v $\therefore v = +2 \text{ m s}^{-1}$

Their common velocity is along the positive direction, i.e. the original direction of P.

70. B

✓ (1) Change in momentum of the ball = (0.2) (−2) − (0.2) (4) = − 1.2 kg m s^{-1}

× (2) Average force acting on the ball by the ground is the normal reaction R :

$R - mg = \frac{mv - mu}{t}$ $\therefore R - (0.2)(9.81) = \frac{1.2}{0.1}$ $\therefore R = 12 + 1.96 = 14.0 \text{ N}$

✓ (3) Since the speed after the collision is smaller, there is loss of KE during the collision.

71. A

① After release, the ball falls down with acceleration due to gravity in downward direction, thus a is downwards and is negative, therefore, (1) is correct as the initial slope is negative.

② The slope of the displacement - time graph is velocity. After release, the magnitude of velocity gradually increases, thus the magnitude of the slope should also gradually increase, therefore, (3) is correct.

72. D

× (1) Initial momentum = $mu + m(-v) > 0$ Final momentum = $m(-u) < 0$ ∴ Momentum is not conserved.

✓ (2) Initial momentum = $mu + m(-v) > 0$ Final momentum = $m(-v) + mu$ ∴ Momentum is conserved.

✓ (3) Initial momentum = $mu + m(-v) > 0$ Final momentum = $mv > 0$ ∴ Momentum is conserved..

73. C

The total momentum must be conserved in the collision. $\therefore m_P u_P = m_P v_P + m_Q v_Q$

× (1) (2) (6) = (2) v_P + (1) (2) $\therefore v_P = 5 \text{ m s}^{-1}$
This situation is impossible since the speed of P cannot be greater than Q in front after collision.

✓ (2) (2) (6) = (2) v_P + (1) (4) $\therefore v_P = 4 \text{ m s}^{-1}$
It is possible since the collision may be inelastic and the two particles move together after collision.

✓ (3) (2) (6) = (2) v_P + (1) (6) $\therefore v_P = 3 \text{ m s}^{-1}$
Total K.E. before collision = $\frac{1}{2}(2)(6)^2 = 36 \text{ J}$
Total K.E. after collision = $\frac{1}{2}(2)(3)^2 + \frac{1}{2}(1)(6)^2 = 27 \text{ J}$
This situation is possible since the collision may be partly elastic with some loss of K.E.

74. B

Area of the F-t graph = change of momentum = $mv - mu$

$\therefore \frac{1}{2} \times (3) \times (10) = (3) v - 0$ $\therefore v = 5 \text{ m s}^{-1}$

75. B

Suppose the ball is thrown up with an initial velocity.

It then moves upwards (v is positive) with constant deceleration g to reach the highest point where its velocity is zero, then moves downward (v is negative) with uniform acceleration g.

The graph should be a straight line with constant slope equal to $-g$.

When the ball reaches the ground, its velocity changes from downward direction to upward direction in a very short time. Thus, the value of v should change sign after impact with the ground.

76. A

✓ (1) During collision, the force acting on P by Q and the force acting on Q by P form an action-reaction pair. Thus, they must be equal in magnitude.

× (2) Since there is no external net force acting on the two balls during collision, the total momentum of the two balls must be conserved no matter the collision is elastic or not.

× (3) Since the collision may not be perfectly elastic, total kinetic energy of the two balls may not conserve. Thus, the loss of *K.E.* of P may not equal to the gain of *K.E.* of Q, as some *K.E.* may change to internal energy.

77. C

Since the bubble is elastic, it can increase the impact time during the collision, thus reduce the impact force to reduce the chance of injury.

The following list of formulae may be found useful :

Gravitational potential energy	$E_P = m g h$
Kinetic energy	$E_K = \frac{1}{2} m v^2$
Mechanical power	$P = F v = \frac{W}{t}$
Force	$F = m \frac{\Delta v}{\Delta t} = \frac{\Delta p}{\Delta t}$

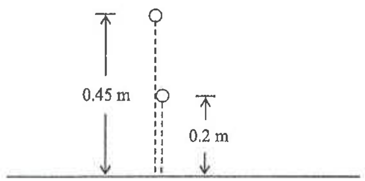
Use the following data wherever necessary :

Acceleration due to gravity $g = 9.81\ m\ s^{-2}$ (close to the Earth)

Part A : HKCE examination questions

1. **< HKCE 1982 Paper I - 1 >**

A metal sphere of mass 0.4 kg is released from a height of 0.45 m onto a marble floor. It rebounds to a height of 0.2 m as shown in the figure below. Assume air resistance is negligible.



(a) Calculate the velocity (magnitude and direction) of the sphere just before and after impact. (4 marks)

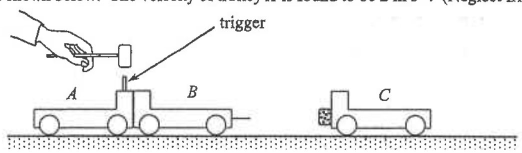
(b) If the sphere is in contact with the floor for 0.01 s, what is the magnitude of the normal reaction force exerted by the floor on the sphere during impact ? (3 marks)

(c) What is the difference in the kinetic energy of the sphere just before and after impact with the floor ? Briefly account for this difference. (4 marks)

1. (d) Sketch a graph showing the variation of the velocity of the sphere with time, starting at the time that the ball is released to the time that the ball reaches its maximum height after the first impact. No need to mark the values.
(Take velocity in the downward direction to be positive.) (4 marks)

2. **< HKCE 1984 Paper I - 1 >**

Trolleys *A*, *B* and *C*, all of the same mass 1 kg, are placed on a horizontal runway with *A* and *B* in contact. Trolley *A* has a compressed spring. When the trigger is tapped, the spring quickly relaxes and the trolleys *A* and *B* start to move apart in opposite directions as shown below. The velocity of trolley *A* is found to be 2 m s^{-1}. (Neglect friction)



(a) What is the velocity of trolley *B* ? (2 marks)

(b) Estimate the potential energy stored in the compressed spring. (3 marks)

(c) Assuming that the time taken for the two trolleys to separate is 0.1 s, find the average force (in magnitude and direction) acting on

(i) trolley *A* , and

(ii) trolley *B*. (4 marks)

(d) After separation, trolley *B* collides with *C* and the two move together.

(i) What is the velocity of the two trolleys, *B* and *C* , after collision ? (2 marks)

(ii) Is the kinetic energy conserved in this case ? If not, calculate the kinetic energy loss. (4 marks)

3. < HKCE 1987 Paper I - 1 >

The mass of a metal ball is 0.5 kg. It is released from rest at a height of 1 m above the floor. Air resistance is assumed to be negligible.

(a) Calculate the speed of the ball just before it strikes the floor. (2 marks)

(b) Calculate the average force the ball would exert on the floor, assuming that the ball was stopped by the floor in 0.1 s and the ball did not rebound. (3 marks)

4. < HKCE 1988 Paper I - 3 >

A private car of mass 900 kg travelling at a speed of 70 km h^{-1} collides head-on with a truck of mass 3000 kg travelling in the opposite direction. Both vehicles are brought to rest by the collision and the duration of the impact is 0.2 s.

(a) What is the speed of the truck just before the impact ? (3 marks)

(b) State whether the magnitude of force acting on the truck is greater than, equal to or smaller than that acting on the private car during the impact. Explain briefly. (3 marks)

(c) If the drivers of both vehicles are taken to be 70 kg, what is the average force acting on

(1) the driver of the private car,

(2) the driver of the truck

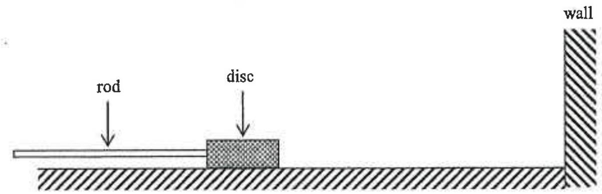
during the collision ?

Which driver is likely to be injured more seriously ? (6 marks)

(d) State ONE design on a vehicle which could reduce the degree of the injury of the driver during impact. Explain briefly. (3 marks)

5. < HKCE 1989 Paper I - 1 >

A disc of mass 0.1 kg is set to move on a frictionless horizontal table by a strike of a rod as shown in the figure below. The average force exerted on the disc by the rod is 50 N. The displacement of the disc while it is in contact with the rod is 0.1 m. Afterwards, the disc collides on a vertical wall at a certain speed and rebounds backwards at the same speed. The time of contact between the disc and the wall is 0.2 s.



(a) (i) Find the work done by the force exerted on the disc by the rod. (2 marks)

(ii) Find the speed of the disc on leaving the rod. (3 marks)

(b) Find the average force exerted on the wall during collision. (4 marks)

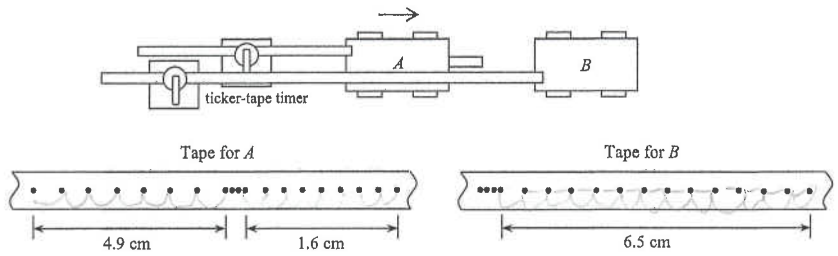
(c) A student makes the following statements concerning the experiment :

Statement 1 : When the disc has left the rod and is moving on the smooth horizontal table, there must be a force driving the disc to keep it moving.

Statement 2 : The faster the disc moves, the greater is the average force exerted on the wall during collision.

State whether statement 1 and statement 2 are true or false and explain briefly using Newton's Laws in each case. (6 marks)

6. **< HKCE 1989 Paper I - 3 >**



The figure above shows two trolleys A and B standing at rest on a friction compensated runway. A is then given a push and collides with B. The ticker tapes obtained from the experiment are also shown in the above diagram. It is given that the ticker-tape timers produce 50 dots per second.

(a) Using the scale on the metre rule as shown above, choose a suitable portion of the tapes and find the speed of

(1) A before the collision,

(2) A after the collision, and

(3) B after the collision. (3 marks)

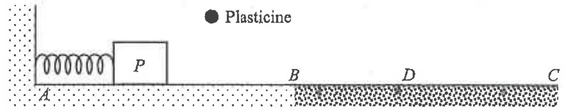
(b) Find the ratio of the mass of A to that of B from (a). (4 marks)

(c) A student reported the following results without doing any experiment :

	A	B
speed before the collision	$0.2\ \text{m s}^{-1}$	0
speed after the collision	$0.1\ \text{m s}^{-1}$	$0.4\ \text{m s}^{-1}$
mass ratio	4 : 1	

If you were the teacher, how would you show that the results are impossible ? (4 marks)

7. **< HKCE 1993 Paper I - 2 >**



The figure above shows a horizontal runway ABC consisting of two parts, a smooth portion AB and a rough portion BC. A block P of mass 0.8 kg undergoes the below motion :

Step (1) : P is pressed against a spring at A and then released. After 0.05 s, P loses contact with the spring and moves with a speed of $1.8\ \text{m s}^{-1}$.

Step (2) : When P moves along AB, a lump of plasticine is dropped from a height slightly above P and sticks to it. The speed of P is reduced to $1.6\ \text{m s}^{-1}$.

Step (3) : P enters the rough portion and stops at point D.

(a) Calculate

(i) the average force acting on the block by the spring in Step (1),

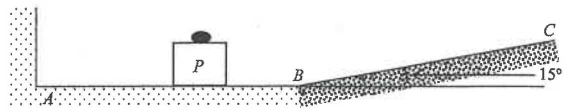
(ii) the mass of the plasticine,

(iii) the distance BD, given that the frictional force between P and the rough portion is 3 N. (7 marks)

(b) Describe the energy change in Step (1). (2 marks)

(c) Is kinetic energy conserved in Step (2) ? Explain briefly. (2 marks)

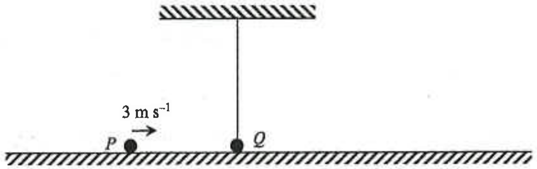
(d)



The above process is repeated with the rough portion BC inclined at an angle 15° to the horizontal. If the frictional force is still 3 N, what happens to P after it reaches the highest point ? Explain your answer. (4 marks)

8. **< HKCE 1994 Paper I - 2 >**

A bob P of mass 0.4 kg moves on a smooth horizontal ground with speed 3 m s^{-1}. A bob Q of mass 0.6 kg is suspended by a light inextensible string as shown in the figure below and is initially at rest. After colliding with Q, P comes to a rest.



(a) Find

(i) the momentum of P before the collision,

(ii) the speed of Q immediately after the collision,

(iii) the average force acting on P during the collision, given that the time of contact is 0.05 s. (5 marks)

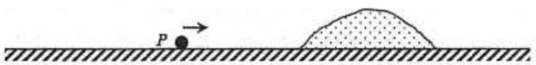
(b) Is the collision elastic ? Show your calculation. (3 marks)

(c) After the collision, bob Q swings upwards.

(i) Find the maximum height reached by Q.

(ii) The string exerts a tension on Q. Is there any work done by the tension when Q swings upwards ? Explain briefly. (5 marks)

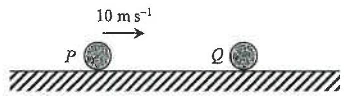
(d)



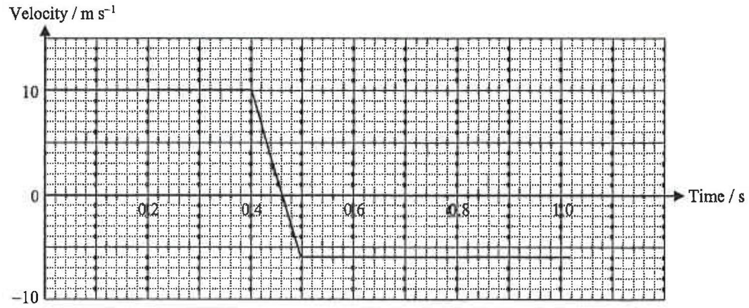
In another experiment, bob P moves towards and sticks to a lump of plasticine, which is fixed to the ground. In this collision, the total momentum of P and the plasticine is not conserved. Explain briefly. (2 marks)

9. **< HKCE 1995 Paper I - 2 >**

(a)



A metal ball P of mass 0.5 kg moves with speed 10 m s^{-1} on smooth horizontal ground. It collides with a heavier metal ball Q, which is initially at rest. After collision, P moves backwards in the opposite direction. The figure below shows the variation of the velocity of P with time.



(i) Find

(1) the momentum of P before the collision,

(2) the change in momentum of P in the collision,

(3) the time of contact of P and Q,

(4) the average force acting on P during the collision. (6 marks)

(ii) Is the average force acting on Q during the collision equal in magnitude to that acting on P ? Explain briefly. (2 marks)

(iii) Comment on the following statement :

"Momentum and kinetic energy must be conserved in this collision." (4 marks)

(b) For safety reasons, the front and rear parts of cars should not be made of very strong material. Explain briefly. (2 marks)

10. < HKCE 1996 Paper I - 3 >

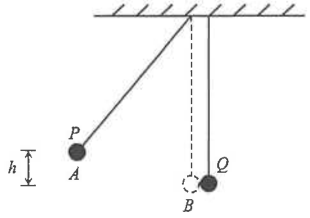


Figure 1

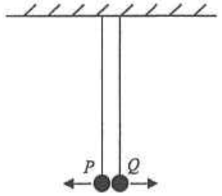


Figure 2

Two metal balls P and Q are suspended by light inextensible strings. Ball P is pulled to a point A which is at a height h above its initial position B and is then released. (See Figure 1.) After colliding at B, the two balls move away in opposite directions. (See Figure 2.)

(a) Draw a diagram to show all the forces acting on P when it swings from A to B. Label the forces. (2 marks)

(b) Describe the energy changes in the two balls, from the moment P is released until the balls swing up to their maximum heights after the collision. (3 marks)

(c) The mass of P is 0.3 kg and its speeds immediately before and after the collision are found to be 1.0 m s^{-1} and 0.5 m s^{-1} respectively.

(i) Find h. (2 marks)

(ii) Find the average force acting on P during the collision, assuming that the time of contact is 0.02 s. (2 marks)

(iii) Consider the following set of data :

	P	Q
Mass / kg	0.3	0.75
Velocity before collision / m s^{-1}	1.0 (towards the right)	0
Velocity after collision / m s^{-1}	0.5 (towards the left)	0.6 (towards the right)

(1) Show that the above set of data obeys the law of conservation of momentum.

(2) Explain why the above set of data is impossible. (5 marks)

11. < HKCE 1998 Paper I - 2 >

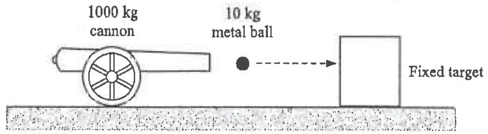


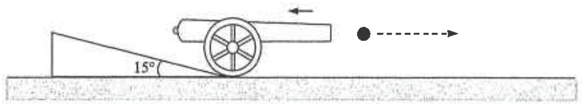
Figure 1 shows a cannon of mass 1000 kg. It fires a metal ball of mass 10 kg in order to destroy a fixed target. Assume the ball travels with a constant horizontal speed of 100 m s^{-1} towards the target.

(a) Suppose that the minimum energy required to destroy the target is 60 000 J. Explain whether the ball will destroy the target. (2 marks)

(b) The cannon recoils as the ball is fired.

(i) Find the recoil speed of the cannon. (2 marks)

(ii)



To stop the cannon, a smooth plane inclined at 15° to the horizontal is placed behind the cannon as shown in the figure. How far will the cannon move up along the inclined plane ? (3 marks)

(c) Suppose that in firing the ball, 80 000 J of energy is lost as heat, light and sound. Find the efficiency of the cannon in firing the ball. Kinetic energy of the ball is considered as the useful energy output. (3 marks)

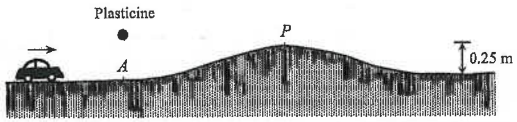
(d) The ball hits the target and becomes embedded in it.

(i) If the ball takes 0.05 s to come to a rest inside the target, find the average force exerted by the target on the ball. (2 marks)

(ii) A student thinks that as the ball and the target are both at rest after the impact, momentum has been lost. He asks why the law of conservation of momentum does not apply in this process.

If you were a teacher, how could you answer this question ? (3 marks)

12. < HKCE 1999 Paper I - 3 >



A toy car of mass 0.2 kg is moving at a speed 3 m s^{-1} on a smooth horizontal runway. When the car passes through a point A on the runway, a lump of plasticine of mass 0.1 kg is dropped from a height slightly above it and sticks to it.

(a) Find the speed of the car after the plasticine sticks to it. (2 marks)

(b) The runway is curved upwards to a height 0.25 m at point P as shown in the above figure. Can the car pass point P ? Show your calculations. (3 marks)

13. < HKCE 2000 Paper I - 4 >

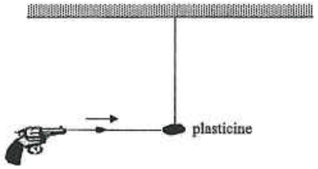
A car of mass 1000 kg moves along a straight road with a speed 10 m s^{-1}. It collides with a lorry of mass 3000 kg, which is initially at rest. Immediately after the collision, the lorry moves forward with a speed 4.5 m s^{-1}. The time of contact of the car and the lorry is 0.5 s. Find

(a) the speed of the car immediately after the collision, (2 marks)

(b) the average force acting on the lorry during the collision, (2 marks)

(c) the average force acting on the car during the collision. (1 mark)

14. < HKCE 2001 Paper I - 1 >



A lump of plasticine of mass 0.2 kg is hanging freely in air from a string as shown in the above figure. A bullet of mass 0.01 kg is fired from an air gun. It hits the plasticine and becomes embedded in it. The plasticine then swings to a maximum height of 0.06 m above its initial position.

(a) Find the speed of the plasticine immediately after the bullet is embedded in it. (2 marks)

(b) Hong Kong Ordinance states that the kinetic energy of bullets fired from air guns should not exceed 2 J. By considering the speed of the bullet before it hits the plasticine, explain why the above gun violates the Ordinance. (3 marks)

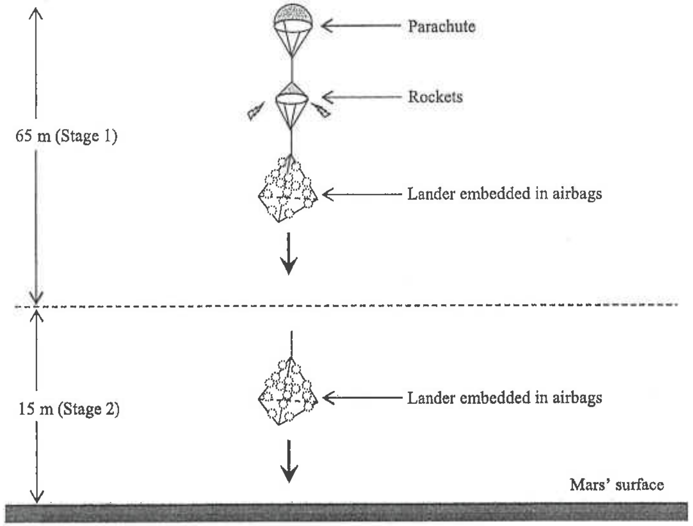
15. < HKCE 2003 Paper I - 3 >

A squash ball of mass 0.024 kg travelling with a horizontal speed of 16 m s^{-1} is hit by a racket. After the impact, the ball travels with a speed of 20 m s^{-1} in the opposite direction. Assume the time of contact between the ball and the racket is 0.15 s.

(a) Find the increase in kinetic energy of the ball. (2 marks)

(b) Find the average force acting on the ball by the racket during the impact. (3 marks)

16. **< HKCE 2003 Paper I - 11 >**



In 4 July, 1997, the lander 'Mars Pathfinder' landed on the surface of Mars. A teacher presents the following simplified information about the last two stages of the landing process as shown in the above figure.

Stage 1 : When the spacecraft (including the lander embedded in some airbags, a parachute and decelerating rockets) was at a height of 80 m above Mars' surface, it was falling with a speed of 75 m s^{-1}. At this instant, the rockets were fired. The parachute and rockets then exerted a total upward force of 16 900 N on the lander and brought it to an instantaneous rest at a height of 15 m above the surface.

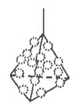
Stage 2 : At the instant when the lander was 15 m above the surface, the parachute and rockets were separated from it. The lander then fell from rest to the surface under the action of the gravity of Mars.

You may assume that the lander descended vertically and the air resistance exerted by the atmosphere on the lander was negligible.

(a) Consider Stage 1 and answer the following :

(i) Find the deceleration of the lander. (2 marks)

(ii) Draw a labelled diagram to show all the forces acting on the lander. (2 marks)



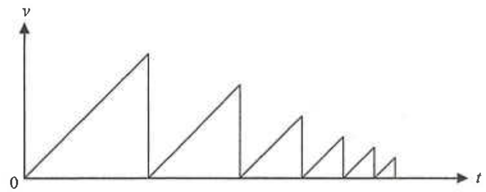
16. (a) (iii) The mass of the lander was 360 kg. Estimate the acceleration due to gravity on Mars' surface. (3 marks)

(b) Consider Stage 2 and answer the following :

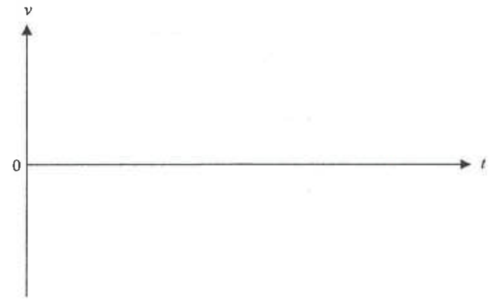
(i) Find the time required for the lander to reach the surface. (2 marks)

(ii) Explain how the airbags helped the lander to land on the surface safely. (2 marks)

(iii) The lander bounced a few times on the surface before coming to rest. As shown in the below figure, a student draws a sketch of the velocity-time graph of the lander, with $t = 0$ denoting the instant when the lander was 15 m above the surface. Assume that the motion took place in a vertical direction.



Explain whether the sketch is correct or not. If it is **incorrect**, draw a correct sketch for the graph. (4 marks)



17. **< HKCE 2006 Paper I - 9 >**

Read the following descriptions about a 'crash cushion system' and answer the questions that follow.

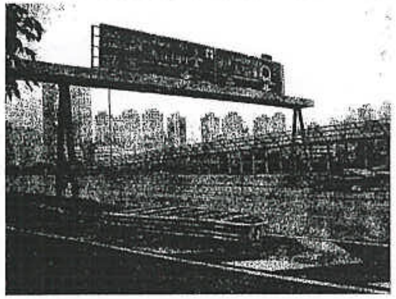


Figure 1

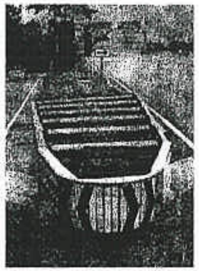


Figure 2

Figure 1 and Figure 2 show a crash cushion system installed at some junctions on highways. The system consists of a number of identical cushion boxes, containing sand or water, lined up and fixed on the road surface. During a crash, the boxes will burst one after another when the car runs through them. The boxes will act as a series of cushions and offer protection to the passengers.

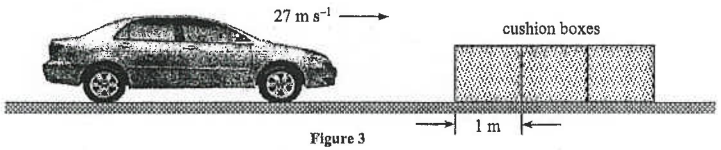


Figure 3

In a pilot test on the cushion boxes, a car of mass 1600 kg travelling at a speed of 27 m s^{-1} runs through the boxes on a road (see Figure 3). The speed v of the car after running through all the boxes is recorded. The test is repeated by varying the number of boxes N installed in the system. The Table below shows the results obtained.

N	1	2	3	4
v / m s^{-1}	25.2	22.8	21.1	18.2

Source : http://www.hk-phy.org/contextual/mechanics/ene/act_crash_cushion_e.html

17. (a) Assume that the deceleration of the car remains unchanged in the test.

(i) Using the data in the Table, plot a graph of v^2 against N in Figure 4, with v^2 ranging from 0 to 1000 m^2 s^{-2} and N from 0 to 10.

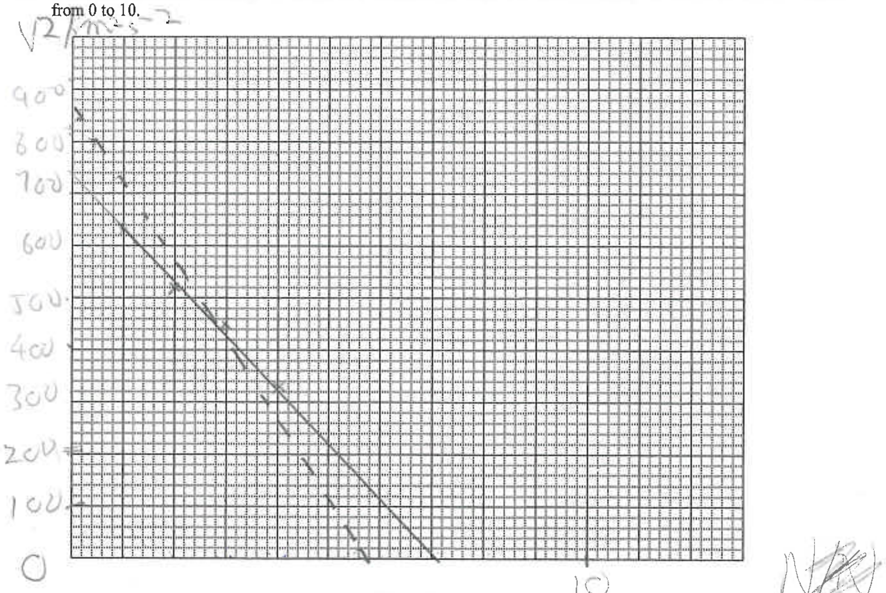


Figure 4

Hence or otherwise, estimate

(1) the average resistive force exerted by the cushion boxes on the car during the collision (given that the thickness of each cushion box is 1 m),

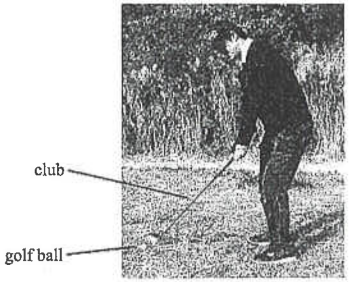
(2) the minimum number of cushion boxes required in order to stop the car in the test. (8 marks)

(ii) If the above test is repeated with a heavier car travelling at an initial speed lower than 27 m s^{-1}, sketch a graph of v^2 against N in Figure 4 that you would expect to obtain. Use a dotted line to sketch the graph. Assume that the average resistive force acting on the car remains unchanged throughout all the tests. (2 marks)

(b) Explain why it is undesirable to replace the cushion boxes with concrete blocks. (2 marks)

18. **< HKCE 2007 Paper I - 9 >**

A golf ball, of mass 40 g and initially at rest, is struck with a club in teeing off as shown in the figure below. The ball leaves the club with a speed of 44 m s^{-1}. Assume that air resistance is negligible.

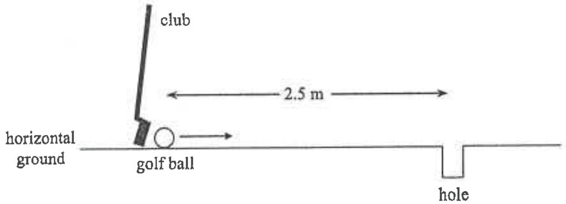


(a) (i) Calculate the change in momentum of the golf ball before and after teeing off. (2 marks)

(ii) The time of impact between the club and the ball during teeing off is 1 ms. Determine the average force acting on the ball during the impact. (2 marks)

(b) Robert finds that the club is harder than the golf ball. He claims that the force exerted on the club is smaller than that exerted on the golf ball during teeing off. Explain whether his claim is correct or not. (2 marks)

(c) When the golf ball is 2.5 m away from the hole, it is given a sharp horizontal push from rest and just reaches the hole as shown below. Estimate the initial speed of the golf ball if the average resistive force exerted on the ball is 0.03 N. (3 marks)



19. **< HKCE 2008 Paper I - 9 >**

Figure 1 shows a cable car system for transporting passengers from station *A* to station *B* on the top of a hill.

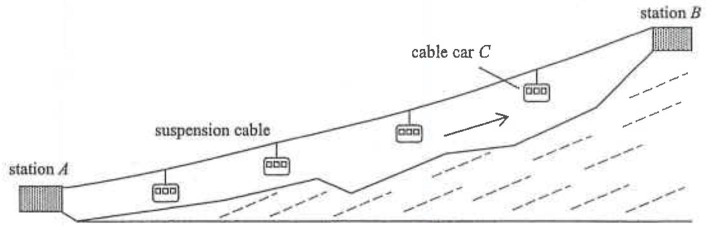


Figure 1

(a) The mass of the cable car *C* is 600 kg. State the magnitude and the direction of its weight. (2 marks)

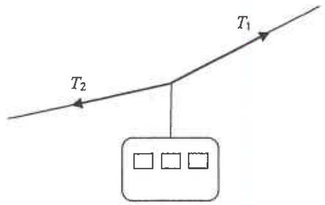


Figure 2

(b) Figure 2 shows cable car *C* which is suspended by the cable with tensions T_1 and T_2 on two sides. The cable car is moving at a constant velocity towards the top of the hill. Assume air resistance is negligible. Complete the vector diagram in Figure 3 to show T_1, T_2 and their resultant T. T_1 is already drawn in the figure. (2 marks)

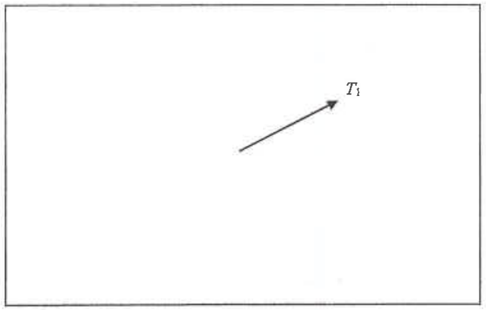


Figure 3

19. (c) The cable car *C* enters terminal *B* with a constant velocity 4.5 m s^{-1} in a horizontal direction. In order to allow the passengers to leave the cabin, the cable car *C* begins to slow down with a constant deceleration after it passes *X*. The velocity is reduced to 0.5 m s^{-1} at *Y* (see Figure 4). Then it moves with a constant velocity again. It takes 8 s for the cable car *C* to travel from *X* to *Y*.

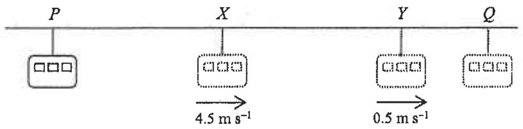


Figure 4

(i) Sketch the velocity-time graph of the cable car for the journey between *X* and *Q* in Figure 5.

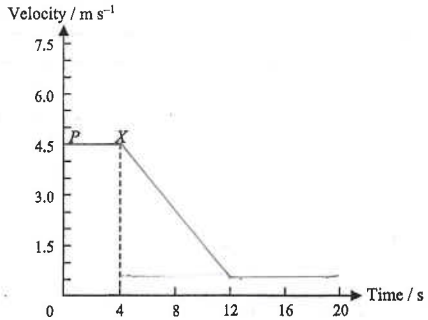


Figure 5

(2 marks)

(ii) Hence or otherwise, find the distance between *X* and *Y*. (2 marks)

Take the direction of the motion of the cable car as the positive direction.

(iii) A 60 kg person sits in the cable car. Find the change of momentum of the person during the journey between *X* and *Y*. (2 marks)

(iv) Hence or otherwise, find the net force acting on the person during the deceleration period. (2 marks)

20. **< HKCE 2010 Paper I - 10 >**

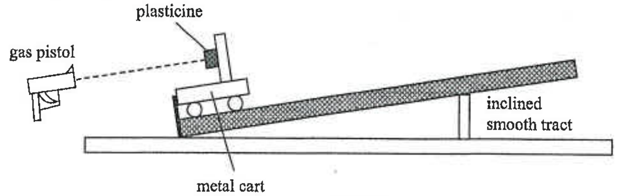


Figure 1

A metal cart with some plasticine fixed on it has a total mass of 40 g. It is initially at rest on an inclined smooth track (see Figure 1). A bullet of mass 0.43 g is shot from a gas pistol towards the car. Upon collision, the bullet is embedded in the plasticine, and the car moves along the track and rises to a maximum vertical distance of 5 cm. Neglect air resistance and take *g* to be 10 m s^{-2}.

(a) State the kind of collision between the bullet and the cart. (1 mark)

(b) Find the speed of the cart just after the collision. (2 mark)

(c) Find the speed of the bullet just before the collision. (2 marks)

(d) Suggest **two reasons** why the maximum potential energy gained by the cart with the embedded bullet is less than the kinetic energy of the bullet just leaving the pistol. (2 marks)

(e) After the first trial, Peter repeats the experiment with the same set up. He makes an error in aiming (see Figure 2) so that the bullet hits the metal part of the cart (instead of the plasticine) and rebounds backward. Describe and explain how this would affect the maximum vertical distance reached by the cart. (3 marks)

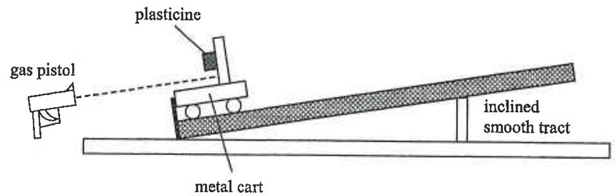


Figure 2

21. **< HKCE 2011 Paper I - 9 >**

Construction workers nowadays must wear safety helmets in construction sites. A safety helmet is made of a hard plastic shell and is held in place on the worker's head by elastic bands as shown in Figure (a).

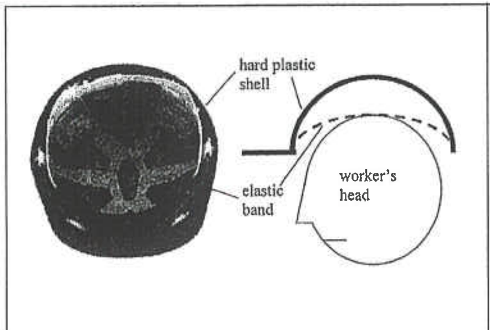


Figure (a)

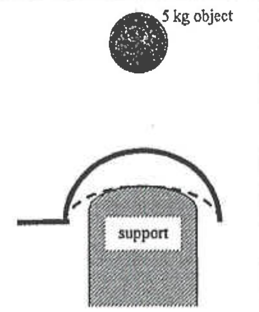
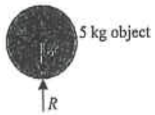


Figure (b)

During a safety test as shown in Figure (b), the helmet is put on a support. A small object of mass 5 kg is released from rest at 1 m above the helmet. The impact time between the object and the plastic shell is found to be 0.03 s. Assume that the object is at rest at the instant the impact ends.

(a) Figure (c) shows the forces acting on the object during the impact.

Figure (c)



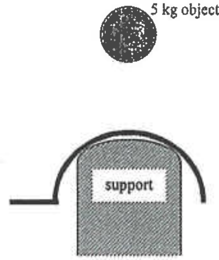
Is R (reaction force from the helmet) and W (weight of the object) an action and reaction pair ? Explain. (2 marks)

(b) (i) Find the speed of the object just before the impact. (1 mark)

(ii) Hence, find the magnitude of the average force acting on the plastic shell by the object during the impact. (4 marks)

21. (c) The safety test is repeated with elastic band removed as shown in Figure (d). It is found that the force acting on the plastic shell by the object becomes much larger during the impact. Hence, explain the function of the elastic band. (2 marks)

Figure (d)



Part B : HKAL examination questions

22. **< HKAL 2005 Paper I - 6 >**

A spacecraft is launched by a rocket. The rocket and the spacecraft have a total initial mass of 4.80×10^5 kg at take-off. The rocket engine propels hot exhaust gas at a constant speed of 2600 m s^{-1} in a downward direction. Assume that 2.30×10^3 kg of gas is expelled in the first second. (Neglect air resistance.)

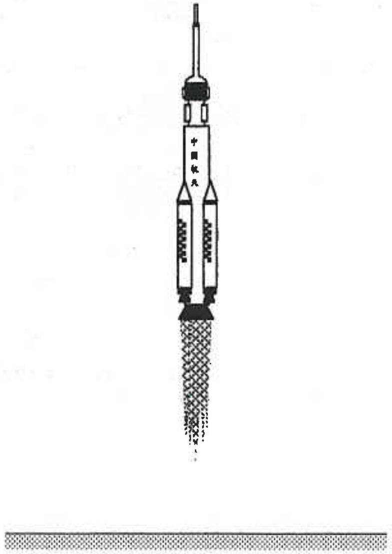
(a) Calculate the average force acting on the rocket due to the exhaust gas during the first second. (3 marks)

(b) Assuming that the change of mass of the rocket during the first second is negligible, estimate the acceleration of the rocket. (2 marks)

(c) If the rocket keeps on expelling exhaust gas at the same rate for the first 20 s, explain how the acceleration of the rocket will change. (2 marks)

Part C : HKDSE examination questions

23. **< HKDSE Sample Paper IB - 11 >**



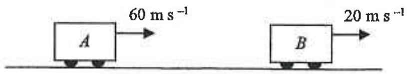
A spacecraft with an astronaut on board is launched on a rocket. The rocket with the spacecraft has an initial mass of 4.80×10^5 kg at take-off. The rocket engine propels hot exhaust gas at a constant speed of 2600 m s^{-1} downwards relative to the rocket. Assume that 1.15×10^3 kg of gas is expelled in the first 0.5 s. (Neglect air resistance.)

(a) Calculate the average force acting on the exhaust gas by the rocket during the first 0.5 s. (2 marks)

(b) In the figure shown, draw and label an arrow for each force acting on the rocket. Assuming that the change in mass of the rocket during the first 0.5 s is negligible, estimate the acceleration of the rocket. (3 marks)

24. **< HKDSE 2012 Paper IB - 4 >**

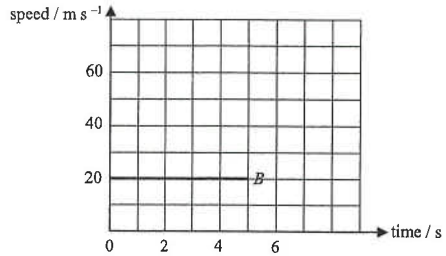
Train A initially travels at a speed of 60 m s^{-1} along a straight horizontal railway. Another identical train B travels ahead of A in the same direction on the same railway. Due to mechanical failure, B is only travelling at 20 m s^{-1}.



At time $t = 0$, A and B are x m apart, the captain of A receives a stopping signal and immediately A decelerates at 4 m s^{-2} while B continues to travel at 20 m s^{-1}. A eventually collides with B after 5 s. Neglect air resistance.

(a) (i) Find the speed of A just before collision. (2 marks)

(ii) The graph below shows how the speed of B varies with time within this 5 s. Sketch on the same graph the variation of the speed of A within the same period. (1 mark)



(iii) Based on the above information, determine the separation x of the two trains at $t = 0$. (3 marks)

(b) A and B locked together after collision.

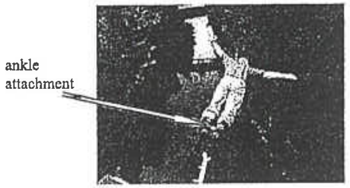
(i) Find the speed of them just after collision. (2 marks)

(ii) If the collision time between the trains is 0.2 s and the mass of each train is 5000 kg, find the magnitude and direction of the average impact force acted on A during collision. (3 marks)

25. **< HKDSE 2014 Paper IB - 6 >**

Read the following description about '**Bungee jumping**' and answer the questions that follow.

Bungee jumping is an activity that involves jumping from a tall structure while the person is connected to it via a thick elastic cord. When the bungee jumper jumps, the cord stretches after falling a certain distance. The bungee jumper is momentarily at rest at the lowest point but then bounces back up into the air. The bungee jumper continues to oscillate up and down a few times before he comes to a complete stop.



A simple 'ankle attachment' (as shown in the above photo) can be used to secure the player to the cord. However, due to accidents where the ankle attachment became detached from the bungee jumper, many operators now uses a 'fully body harness'.

When answering the following questions, neglect the effects of air resistance.

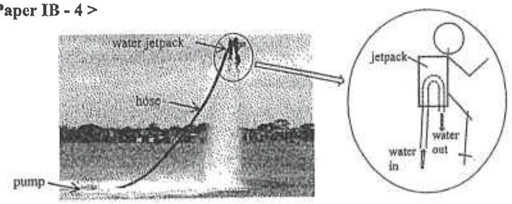
(a) (i) Describe the acceleration of the bungee jumper during the first downward fall to the lowest point. (3 marks)

(ii) State the energy change during the period from the beginning of the jump to the moment when the bungee jumper is at the lowest point of his first downward fall. (2 marks)

(b) In terms of the net force acting on the bungee jumper, explain why the cord has to be elastic. (2 marks)

(c) In terms of contact area, explain why a 'full body harness' is less likely to cause injuries to or detach from the bungee jumper than a simple 'ankle attachment' during a fall. (2 marks)

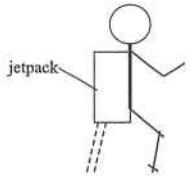
26. **< HKDSE 2016 Paper IB - 4 >**



A person wears a water jetpack which enables him to stay 'afloat' in equilibrium in the air as shown in the above figure. A pump on the sea surface continuously pumps water to the jetpack via a hose and the water is then ejected downwards.

(a) Referring to the above figure, water enters the U-shape hose inside the jetpack with a certain speed and is then ejected out vertically downwards. Use Newton's law(s) of motion to explain why a lifting force acting on the person is produced. (3 marks)

(b) Draw and label all the forces acting on the person wearing the jetpack as a whole in the free-body diagram below. Neglect the pulling force due to the hose connected to the jetpack. (1 mark)



(c) Suppose that water enters the jetpack with a speed of 10 m s^{-1} vertically upwards and is then ejected out at the same speed vertically downwards. Take $g = 9.81$ m s^{-2}.

(i) Just by considering the change of momentum of the water, estimate how much water, in kg, has to be ejected per second to provide a lifting force of 1000 N needed. (2 marks)

(ii) Water is pumped continuously to the water jetpack at a height of 7.5 m above sea surface and then ejected from it. By considering the gain in mechanical energy of the water, estimate the minimum output power of the pump. (3 marks)

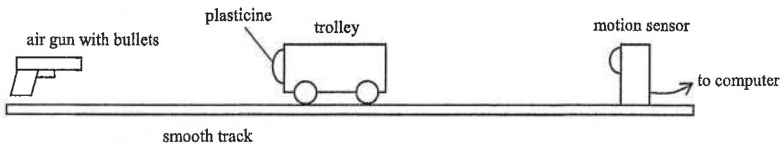
(d) The person changes to stay 'afloat' in equilibrium at a higher position. If the speed by which water enters and is ejected from the jetpack remains the same, would the amount of water ejected per second be greater than, equal to or smaller than the result found in (c) (i) ? Explain. (Neglect the weight of the hose.) (2 marks)

27. **< HKDSE 2017 Paper IB - 2 >**

The following experimental items are provided to set up an experiment to estimate the speed of a bullet fired from an air gun.

a smooth track
a trolley
a motion sensor used to measure the speed of the trolley
some plasticine
an air gun and bullets
an electronic balance

The set-up is shown in the following figure.



Describe the procedures of the experiment. State the physical quantities to be measured and an equation for finding the speed of the bullet. Write down **ONE** precaution for getting a more accurate result. (5 marks)

HKEAA's Marking Scheme is prepared for the markers' reference. It should not be regarded as a set of model answers. Students and teachers who are not involved in the marking process are advised to interpret the Marking Scheme with care.

Question Solution

1. (a) $m g h = \frac{1}{2} m v^2$

$\therefore\ v = \sqrt{2 g h}$ [1]

Velocity before impact $= \sqrt{2 \times 9.81 \times 0.45} = 2.97 \text{ m s}^{-1}$ (downwards) [1]

Velocity after impact $= \sqrt{2 \times 9.81 \times 0.2} = 1.98 \text{ m s}^{-1}$ (upwards) [2]

(b) $R - m g = \dfrac{m v - m u}{t}$ [1]

$R - (0.4)(9.81) = \dfrac{(0.4)(1.98) - (0.4)(-2.97)}{0.01}$ [1]

$R = 202 \text{ N}$ [1]

(c) $\Delta KE = \frac{1}{2} m v^2 - \frac{1}{2} m u^2$ [1]

$= \frac{1}{2}(0.4) \times (2.97)^2 - \frac{1}{2}(0.4) \times (1.98)^2 = 0.98 \text{ J}$ [1]

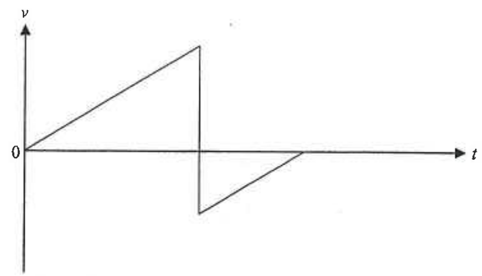
KE decreases [1]

since some kinetic energy changes to internal energy during impact. [1]

OR

the collision is not elastic. [1]

(d)



< initial portion is positive > [1]

< all straight line > [1]

< changes to negative during impact > [1]

< speed smaller after impact > [1]

2. (a) $m_A u_A + m_B u_B = m_A v_A + m_B v_B$ [1]

$0 = (1) \times (-2) + (1) \times v_B$

$\therefore\ v_B = 2 \text{ m s}^{-1}$ [1]

2. (b) Total KE after separation $= \frac{1}{2} m_A v_A^2 + \frac{1}{2} m_B v_B^2$ [1]

$= \frac{1}{2}(1)\times(2)^2 + \frac{1}{2}(1)\times(-2)^2 = 4$ J [1]

Potential energy stored in spring = 4 J [1]

(c) $F_A = \dfrac{m_A v_A - m_A u_A}{t} = \dfrac{(1)(-2)-0}{0.1} = -20$ N [2]

$F_B = 20$ N [1]

Direction : F_A – towards the left F_B – towards the right [1]

(d) (i) $m_B u_B + m_C u_C = m_B v_B + m_C v_C$ [1]

$(1)\times(2) + 0 = (1+1)v$ $\therefore v = 1 \text{ m s}^{-1}$ [1]

(ii) No ! [1]

KE before impact $= \frac{1}{2}(1)\times(2)^2 = 2$ J [1]

KE after impact $= \frac{1}{2}(1+1)\times(1)^2 = 1$ J [1]

KE lost $= 2 - 1 = 1$ J [1]

3. (a) By $v^2 = u^2 + 2as$ $\therefore v^2 = 0 + 2\times(9.81)\times(1)$ [1]

$\therefore v = 4.43 \text{ m s}^{-1}$ [1]

OR

By $mgh = \frac{1}{2}mv^2$ $\therefore (9.80)(1) = \frac{1}{2}v^2$ [1]

$\therefore v = 4.43 \text{ m s}^{-1}$ [1]

(b) Average force R acting on the ball by the floor : $R - mg = \dfrac{mv - mu}{t}$ [1]

$\therefore R - (0.5)(9.81) = \dfrac{(0.5)(0) - (0.5)(-4.43)}{(0.1)}$ $\therefore R = 27.1$ N [1]

By Newton's 3rd law, average force acting on floor by the ball is 27.1 N. [1]

4. (a) $u = \dfrac{70\times1000}{3600} = 19.44 \text{ m s}^{-1}$

By $m_1 u_1 + m_2 u_2 = m_1 v_1 + m_2 v_2$ [1]

$\therefore (900)(19.44) + (3000)u_2 = 0$ [1]

$\therefore u_2 = -5.83 \text{ m s}^{-1}$

$\therefore$ speed of truck is 5.83 m s^{-1} [1]

(b) Both vehicles will experience equal magnitude of force. [1]

Since the two forces are action and reaction pair. [1]

By Newton's third law, they must be equal in magnitude. [1]

4. (c) For the private car driver

$F = \dfrac{mv - mu}{t}$ [1]

$= \dfrac{0-(70)(19.44)}{0.2}$ [1]

$= -6800$ N [1]

For the truck driver

$F = \dfrac{mv - mu}{t} = \dfrac{0-(70)(-5.83)}{0.2}$ [1]

$= 2040$ N [1]

The private car driver will be injured more seriously. [1]

(d) Seat belt [1]

To prevent the driver from throwing forward and hitting the glass. [2]

(or Seat belt is elastic to increase the time of impact, thus decrease the impact force.) [2]

OR

Bumper of the car collapsible during impact [1]

To increase the duration time of impact and thus reduce the impact force. [2]

5. (a) (i) $W = Fs = (50)\times(0.1)$ [1]

$= 5$ J [1]

(ii) Work done by force = KE gained by disc [1]

$\therefore (5) = \frac{1}{2}(0.1)v^2$ [1]

$\therefore v = 10 \text{ m s}^{-1}$ [1]

(b) $F = \dfrac{mv - mu}{t}$ [1]

$= \dfrac{(0.1)(10)-(0.1)(-10)}{0.2}$ [2]

$= 10$ N [1]

(c) Statement 1 – false [1]

Reason : By Newton's 1st law, the disc will keep on moving with uniform velocity [1]

even when there is no net force acting on it. [1]

Statement 2 – true [1]

Reason : The greater the speed, the greater the change of momentum.

By Newton's 2nd law, force is proportional to the rate of change of momentum [1]

$\therefore$ The force is greater. [1]

6. (a) (1) $u_A = \dfrac{4.9}{7\times 0.02} = 35\text{ cm s}^{-1}$ [1]

(2) $v_A = \dfrac{1.6}{8\times 0.02} = 10\text{ cm s}^{-1}$ [1]

(3) $v_B = \dfrac{6.5}{13\times 0.02} = 25\text{ cm s}^{-1}$ [1]

(b) $m_A u_A + m_B u_B = m_A v_A + m_B v_B$ [1]

$m_A (35) + 0 = m_A (10) + m_B (25)$ [1]

$\therefore \quad m_A : m_B = 1$ [2]

(c) Total KE before collision $= \frac{1}{2}\times(4)\times(0.2)^2 = 0.08$ [1]

Final KE after collision $= \frac{1}{2}\times(4)\times(0.1)^2 + \frac{1}{2}\times(1)\times(0.4)^2 = 0.10$ [1]

By the Principle of conservation of energy, it is impossible that the kinetic energy after collision becomes greater than the kinetic energy before collision. [2]

7. (a) (i) $F = \dfrac{mv - mu}{t} = \dfrac{(0.8)(1.8)-(0.8)(0)}{0.05}$ [1]

$= 28.8\text{ N}$ [1]

(ii) $m_1 u_1 + m_2 u_2 = m_1 v_1 + m_2 v_2$

$(0.8)\times(1.8) + 0 = (0.8 + m)\times(1.6)$ [1]

mass of plasticine $m = 0.1\text{ kg}$ [1]

(iii) Work done against friction = loss in kinetic energy [1]

$(3)\times s = \frac{1}{2}(0.9)\times(1.6)^2$ [1]

$\therefore s = 0.384\text{ m}$ [1]

(b) Chemical energy is changed into elastic potential energy stored in the spring, [1]
which is then changed into kinetic energy of the block when it is released. [1]

(c) Kinetic energy is not conserved because the collision between the block and the plasticine is inelastic. [1]
Some energy is changed into internal energy during the collision. [1]

(d) After the block reaches the highest point, it will stop and remain at rest at that point [1]
because component of weight along the plane $= m\,g\sin\theta$ [1]

$= 0.9\times 9.81\times\sin 15° = 2.29\text{ N}$ [1]

which is smaller than the frictional force. [1]

8. (a) (i) Momentum of $P = m\,v = 0.4\times 3 = 1.2\text{ kg m s}^{-1}$ [1]

(ii) $m_1 u_1 + m_2 u_2 = m_1 v_1 + m_2 v_2$ [1]

$1.2 + 0 = 0 + (0.6)\times v \qquad \therefore v = 2\text{ m s}^{-1}$ [1]

(iii) $F = \dfrac{mv - mu}{t} = \dfrac{(0.4)(0)-(0.4)(3)}{0.05} = -24\text{ N}$ [2]

(b) Initial K.E. $= \frac{1}{2}(0.4)\times(3)^2 = 1.8\text{ J}$ [1]

Final K.E. $= \frac{1}{2}(0.6)\times(2)^2 = 1.2\text{ J}$ [1]

Since K.E. is lost in the collision, it is not elastic. [1]

(c) (i) $m\,g\,h = \frac{1}{2}m\,v^2$ [1]

$(0.6)\times(9.81)\,h = \frac{1}{2}(0.6)\times(2)^2 \qquad \therefore h = 0.204\text{ m}$ [1]

(ii) There is no work done [1]
because the tension is always perpendicular to the motion of the bob. [2]

(d) An external force acts on the plasticine [1]
by the ground during the collision. [1]

OR

The total momentum of P, the plasticine and the Earth is conserved. [2]

9. (a) (i) (1) Momentum of P before collision $= 0.5\times 10 = 5\text{ kg m s}^{-1}$ [1]

(2) Change in momentum of $P = m\,v - m\,u$ [1]

$= (0.5)\times(-6) - (0.5)\times(10) = -8\text{ kg m s}^{-1}$ [1]

(3) Time of contact = 0.1 s [1]

(4) Average force on $P = \dfrac{mv - mu}{t} = \dfrac{-8}{0.1}$ [1]

$= -80\text{ N}$ [1]

(ii) Yes! The average force acts on Q is equal in magnitude to that acting on P [1]
because the two forces are action and reaction pair according to Newton's 3rd law. [1]

(iii) Momentum must be conserved [1]
because there is no external force acting on P and Q during the collision. [1]
However kinetic energy may or may not be conserved. [1]
It depends on whether the collision is elastic or not. [1]

(b) If the car is made of very strong material, it will be brought to rest in a very short time during a collision. [1]
A large force then acts on the passengers which may cause serious injuries. [1]

10. (a)

< label with T or tension > [1]

< label with W, mg or weight > [1]

(b) When P swings from A to B, its potential energy is converted to kinetic energy. [1]

When P collides with Q, some of its kinetic energy is converted to the kinetic energy of Q. [1]

When P and Q swing upward after impact,
their kinetic energies are converted back into potential energies. [1]

(c) (i) By conservation of energy,

$\frac{1}{2} m v^2 = m g h$ [1]

$\therefore \frac{1}{2} \times (1)^2 = (9.81) \times h$

$\therefore h = 0.0510$ m [1]

(ii) Average force $= \dfrac{mv - mu}{t}$

$= \dfrac{(0.3)(0.5) - (0.3)(-1)}{0.02}$ **OR** $= \dfrac{(0.3)(-0.5) - (0.3)(1)}{0.02}$ [1]

$= 22.5$ N $\quad = -22.5$ N [1]

(iii) (1) Momentum before collision $= 0.3 \times (1.0) + 0.75 \times (0) = 0.3$ kg m s^{-1} [1]

Momentum after collision $= 0.3 \times (-0.5) + 0.75 \times (0.6) = 0.3$ kg m s^{-1} [1]

$\therefore$ Momentum is conserved in the collision.

(2) Total kinetic energy before the collision $= \frac{1}{2}(0.3) \times (1.0)^2 = 0.15$ J [1]

Total kinetic energy after the collision $= \frac{1}{2}(0.3) \times (0.5)^2 + \frac{1}{2}(0.75) \times (0.6)^2 = 0.1725$ J [1]

Since the kinetic energy after the collision increases, the data are impossible. [1]

11. (a) Kinetic energy of the ball $= \frac{1}{2} m v^2 = \frac{1}{2} \times 10 \times 100^2 = 50000$ J [1]

As the kinetic energy of the ball is less than 60000 J, so the ball cannot destroy the target. [1]

(b) (i) By conservation of momentum,

$1000\ V = 10 \times 100$ [1]

$\therefore V = 1$ m s^{-1} [1]

11. (b) (ii) $\frac{1}{2} m v^2 = m g h = m g s \sin\theta$ [1]

$\frac{1}{2} \times 1000 \times 1^2 = 1000 \times 9.81 \times s \sin 15°$ [1]

$\therefore s = 0.197$ m [1]

(c) Total input energy $=$ KE of cannon $+$ KE of ball $+$ energy loss [1]

$= \frac{1}{2} \times 1000 \times 1^2 + \frac{1}{2} \times 10 \times 100^2 + 80000$

$= 130500$ J

Efficiency $= \dfrac{\text{useful output energy}}{\text{total input energy}} \times 100\%$ [1]

$= \dfrac{50000}{130500} \times 100\% = 38.3\%$ [1]

(d) (i) $F = \dfrac{mv - mu}{t}$ [1]

$= \dfrac{0 - 10 \times 100}{0.05}$

$= -20000$ N [1]

(ii) Momentum of the ball and the target is not conserved [1]

because there is an external force [1]

acting on the target by the ground. [1]

< OR >

The total momentum of the ball, the target together with the Earth is conserved. [3]

12. (a) By Conservation of momentum,

$m_1 u_1 + m_2 u_2 = m_1 v_1 + m_2 v_2$

$(0.2) \times (3) = (0.2 + 0.1)\ v$ [1]

$\therefore v = 2$ m s^{-1} [1]

(b) Total kinetic energy of the car and plasticine $= \frac{1}{2} m v^2$

$= \frac{1}{2} \times (0.3) \times (2)^2$

$= 0.6$ J [1]

Potential energy gained by the car in order to reach $P = m g h$

$= (0.3) \times (9.81) \times (0.25)$

$= 0.736$ J [1]

Since the KE is less than the PE, the car cannot pass P. [1]

13. (a) $m_1 u_1 + m_2 u_2 = m_1 v_1 + m_2 v_2$ [1]

$(1000) \times (10) + (3000) \times (0) = (1000) v_1 + (3000) \times (4.5)$

$v_1 = -3.5 \text{ m s}^{-1}$ [1]

(b) $F_2 = \dfrac{mv - mu}{t}$

$= \dfrac{3000 \times 4.5 - 0}{0.5}$ [1]

$= 27000 \text{ N}$ [1]

(c) $F_1 = \dfrac{mv - mu}{t} = \dfrac{(1000)\times(-3.5)-(1000)\times(10)}{0.5}$

$= -27000 \text{ N}$ [1]

14. (a) Loss in KE = Gain in PE

$\therefore \ \frac{1}{2} m v^2 = m g h$ [1]

$\therefore \ v^2 = 2 g h = 2 \times 9.81 \times 0.06$

$\therefore \ v = 1.08 \text{ m s}^{-1}$ [1]

(b) $m_1 u_1 + m_2 u_2 = m_1 v_1 + m_2 v_2$

$(0.01) u_1 = (0.01 + 0.2)(1.08)$

$\therefore \ u_1 = 22.7 \text{ m s}^{-1}$ [1]

Kinetic energy of the bullet $= \frac{1}{2} m v^2$ [1]

$= \frac{1}{2} (0.01)(22.7)^2$

$= 2.58 \text{ J} > 2 \text{ J}$ [1]

$\therefore$ The gun violates the ordinance.

15. (a) Increase of KE $= \frac{1}{2} m v^2 - \frac{1}{2} m u^2$

$= \frac{1}{2} (0.024)(20)^2 - \frac{1}{2} (0.024)(16)^2$ [1]

$= 1.728 \text{ J}$ [1]

(b) Average force on the ball $= \dfrac{mv - mu}{t}$ [1]

$= \dfrac{(0.024)(20) - (0.024)(-16)}{0.15}$ [1]

$= 5.76 \text{ N}$ [1]

16. (a) (i) $v^2 = u^2 + 2as$

$(0) = (75)^2 + 2a(65)$ [1]

$a = -43.27 \approx -43.3 \text{ m s}^{-2}$ [1]

(ii)

[1]

[1]

(iii) $T - W = m a$

$(16900) - W = (360)(43.27)$ [1]

$W = 1322.8 \text{ N}$ [1]

$g = \dfrac{W}{m} = \dfrac{(1322.8)}{(360)} = 3.67 \text{ m s}^{-2}$ < accept 3.64 m s^{-2} > [1]

OR

$T - mg = m a$ [1]

$(16900) - (360) g = (360)(43.27)$ [1]

$g = 3.67 \text{ m s}^{-2}$ < accept 3.64 m s^{-2} > [1]

(b) (i) $s = ut + \frac{1}{2} a t^2$

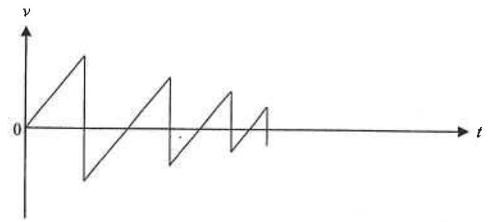
$\therefore \ (15) = (0) + \frac{1}{2} (3.64) t^2$ [1]

$\therefore \ t = 2.87 \text{ s}$ [1]

(ii) They are elastic to increase the duration time of impact [1]
and thus reduce the impact force on landing. [1]

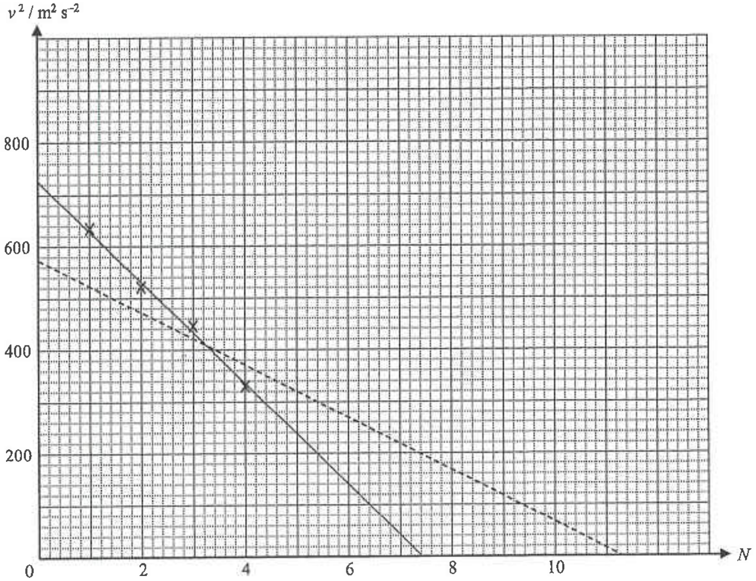
(iii) The sketch is not correct since the velocity should have positive and negative values [1]
as the direction of the velocity of the lander may be upwards and downwards during the bouncing.

[3]



17. (a) (i)

N	1	2	3	4
v / m s^{-1}	25.2	22.8	21.1	18.2
v^2 / m^2 s^{-2}	635	520	445	331



< Correct label of two axes with correct unit > [1]

< Suitable scale > [1]

< Points plotted correctly > [1]

< Straight line drawn > [1]

(1) When $v^2 = 0$, $N = 7.4$ < 7.2 to 8.0 acceptable >

Stopping distance = 7.4 m

By $\frac{1}{2} m u^2 = F s$ [1]

$\therefore \frac{1}{2}(1600)(27)^2 = F(7.4)$ [1]

$\therefore F = 78800$ N < 70000 to 84800 acceptable > [1]

(2) Minimum number of boxes = 8 [1]

(ii) < Magnitude of the slope is smaller > [1]

< Smaller y-intercept > (x-intercept may be greater or smaller than the original one) [1]

(b) The time of collision would become smaller, [1]

and thus the impact force would become greater. [1]

18. (a) (i) Change of momentum $= mv - mu$ [1]

$= (0.04)(44) - 0$

$= 1.76$ N s [1]

(ii) Average force $= \dfrac{mv - mu}{t} = \dfrac{(1.76)}{(1\times10^{-3})}$ [1]

$= 1760$ N [1]

(b) He is not correct [1]

since they are action and reaction pair, the force exerted on the club is equal to that exerted on the ball. [1]

(c) $\frac{1}{2} m u^2 = f s$ [1]

$\frac{1}{2}(0.04) u^2 = (0.03)(2.5)$ [1]

$u = 1.94$ m s^{-1} [1]

< OR >

$F = ma$ $\therefore (-0.03) = (0.04)a$ $\therefore a = -0.75$ m s^{-2} [1]

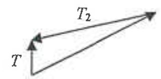
$v^2 = u^2 + 2as$ [1]

$(0) = u^2 + 2(-0.75)(2.5)$ $\therefore u = 1.94$ m s^{-1} [1]

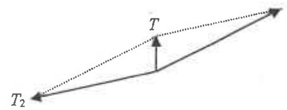
19. (a) 6000 N [1]

downwards [1]

(b)



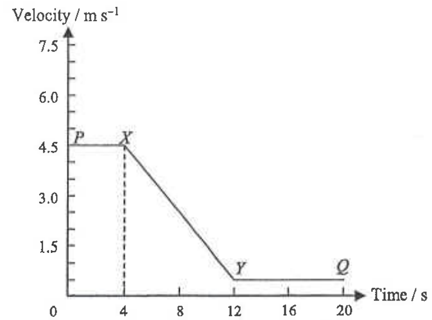
OR



< tip-to-tail method or parallelogram > [1]

< resultant T is vertical and upward > [1]

(c) (i)



< XY : straight line with negative slope and Y is at 12 s and 0.5 m s^{-1} > [1]

< YQ : horizontal straight line, velocity at 0.5 m s^{-1} > [1]

19. (c) (ii) XY = area under the graph between X and Y [1]

$= \frac{1}{2}(4.5 + 0.5) \times (8)$

$= 20\text{ m}$ [1]

OR

a = slope = -0.5 m s^{-2} [1]

$s = ut + \frac{1}{2}at^2$ **OR** $v^2 = u^2 + 2as$

$s = (4.5)(8) + \frac{1}{2} \times (-0.5)(8)^2$; $(0.5)^2 = (4.5)^2 + 2(-0.5)s$

$s = 20\text{ m}$; $s = 20\text{ m}$ [1]

(iii) Change of momentum $= mv - mu$ [1]

$= (60)(0.5 - 4.5)$

$= -240\text{ N s}$ (OR -240 kg m s^{-1}) [1]

(iv) Net force = change of momentum / time

$= -\frac{240}{8}$ [1]

$= -30\text{ N}$ [1]

OR

Net force $= ma$ [1]

$= (60)(-0.5)$

$= -30\text{ N}$ [1]

20. (a) inelastic collision [1]

(b) $\frac{1}{2}mv^2 = mgh$ [1]

$\frac{1}{2}v^2 = (10)(0.05)$

$\therefore v = 1\text{ m s}^{-1}$ [1]

(c) $m_1 u = (m_1 + m_2)v$ [1]

$(0.43)u = (0.43 + 40)(1)$

$\therefore u = 94.0\text{ m s}^{-1}$ [1]

(d) Mechanical energy (OR kinetic energy) is lost during the inelastic collision between the bullet and the cart. [1]

Some kinetic energy of the bullet changes to potential energy before it hits the cart. [1]

(e) Maximum height reached increases. [1]

As the bullet rebounds after the collision, its change of momentum increases. [1]

By the law of conservation of momentum, the momentum of the cart increases, thus it rises to a higher height. [1]

21. (a) The forces are not action and reaction pair. [1]

It is because (any **ONE** of the following) [1]

* they are acting on the same object
* they have different magnitude
* they belong to different type of force

(b) (i) $v^2 = u^2 + 2as = 0 + 2(9.81)(1)$ $\therefore v = 4.43\text{ m s}^{-1}$ [1]

OR

$mgh = \frac{1}{2}mv^2$ $\therefore (9.81)(1) = \frac{1}{2}v^2$ $\therefore v = 4.43\text{ m s}^{-1}$

(ii) Average force R acting on the object by the shell :

$R - mg = \frac{mv - mu}{t}$ [1]

$R - (5)(9.81) = \frac{0 - (5)(-4.43)}{0.03}$ [1]

$R = 787\text{ N}$ [1]

By Newton's 3rd law, the magnitude of the average force acting on the shell by the object = 787 N [1]

(c) The elastic extends during the impact. [1]

The impact time becomes longer, thus the average force becomes smaller. [1]

OR

Without the elastic band, the impact time becomes shorter. [1]

22. (a) Force on the exhaust gases :

$F = \frac{mv - mu}{t} = \frac{m}{t}(v - u) = (2.30\times10^3)(2600 - 0)$ [1]

$= 5.98 \times 10^6\text{ N}$ [1]

By Newton's third law of action-reaction, force acting on the rocket by the exhaust gases is 5.98×10^6 N. [1]

(b) $F - mg = ma$ [1]

$(5.98 \times 10^6) - (4.80 \times 10^5)(9.81) = (4.80 \times 10^5)a$

$\therefore a = 2.65\text{ m s}^{-2}$ [1]

(c) Since the average thrust remains unchanged, as the mass of the rocket gradually decreases, [1]

the acceleration of the rocket would gradually increase. [1]

23. (a) $F = \frac{m}{t}(v - u) = \frac{(1.15\times10^3)}{(0.5)} \times (2600 - 0)$ [1]

$= 5.98 \times 10^6\text{ N}$ [1]

23. (b)

[1]

$F - Mg = Ma$ [1]

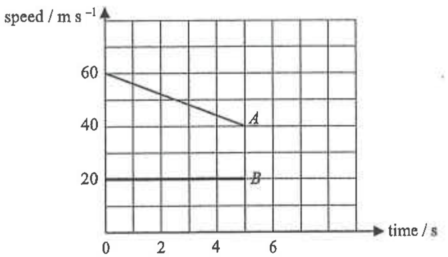
$(5.98 \times 10^6) - (4.80 \times 10^5)(9.81) = (4.80 \times 10^5)\, a$

$a = 2.65 \text{ m s}^{-2}$ [1]

24. (a) (i) $v = u + at = (60) + (-4)(5)$ [1]

$= 40 \text{ m s}^{-1}$ [1]

(ii)



[1]

(iii) Distance travelled by A = $\frac{1}{2}(40 + 60) \times (5) = 250$ m [1]

Distance travelled by B = $20 \times 5 = 100$ m [1]

Separation $x = 250 - 100 = 150$ m [1]

OR

$x = \frac{1}{2}(40 + 60) \times (5) - 20 \times 5$ [2]

$= 150$ m [1]

(b) (i) $m_1 u_1 + m_2 u_2 = (m_1 + m_2) v$

$(m)(40) + (m)(20) = (m + m) v$ [1]

$v = 30 \text{ m s}^{-1}$ [1]

(ii) $F_A = \dfrac{mv - mu}{t} = \dfrac{(5000)(30) - (5000)(40)}{(0.2)}$ [1]

$= -250\,000$ N [1]

The magnitude of the impact force on A is 250 000 N and in the backward (**OR** leftward) direction. [1]

25. (a) (i) Before the elastic cord stretches, the acceleration of the jumper is equal to g. [1]

As the cord stretches, the acceleration of the jumper decreases. [1]

As the cord further stretches that the tension is greater than mg, the jumper decelerates until it comes to rest. [1]

(ii) At the beginning, gravitational potential energy of the jumper changes to its kinetic energy, [1]

and then to the elastic potential energy of the cord at the lowest point. [1]

(b) Elastic cord increases the stopping time, [1]

thus reduces the force acting on the player. [1]

(c) The contact area is larger, [1]

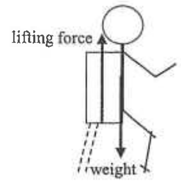
hence the pressure is smaller during the fall and thus less likely to cause injuries. [1]

26. (a) By Newton's second law, a force acts on the water to change its momentum from upwards to downwards. [1]

By Newton's third law, [1]

as a force acts downwards on the water by the jetpack, the water exerts an upward reaction on the jetpack. [1]

(b)



< upward lifting force and downward weight drawn and labelled correctly > [1]

[weight can be labelled with W or mg] [lifting force labelled with F is not accepted]

(c) (i) $F = \dfrac{m}{t}(v - u)$ [1]

$\therefore\ (1000) = \dfrac{m}{t}[(10) - (-10)]$

$\therefore\ \dfrac{m}{t} = 50 \text{ kg s}^{-1}$ [1]

(ii) Consider time of 1 s.

Work done by the pump = gain of PE + gain of KE

$\therefore\ W = mgh + \frac{1}{2}mv^2$ [1]

$= (50)(9.81)(7.5) + \frac{1}{2}(50)(10)^2$ [1]

$= 6180$ J

$\therefore\ P = 6180$ W [1]

(d) To stay afloat in equilibrium, same lifting force is required. [1]

Thus, amount of water ejected per second would be the same. [1]

27. Measure the mass of a bullet m and the mass of the trolley with plasticine M. [1]

Fire the bullet towards the plasticine. [1]

Read the speed of the trolley v immediately after the bullet hit the plasticine. [1]

By conservation of the momentum,

$m u = (M + m) v$

Speed u of the bullet is found by $u = \frac{M + m}{m} v$ [1]

Precaution : (any **ONE** of the following) [1]

* The bullet should be fired close to the plasticine.
* The bullet should be fired along the direction of travel of the trolley.
* The track must be horizontal.

Hong Kong Diploma of Secondary Education Examination

Physics – Compulsory part (必修部分)

Section A – Heat and Gases (熱和氣體)
1. Temperature, Heat and Internal energy (溫度、熱和內能)
2. Transfer Processes (熱轉移過程)
3. Change of State (形態的改變)
4. General Gas Law (普通氣體定律)
5. Kinetic Theory (分子運動論)

Section B – Force and Motion (力和運動)
1. Position and Movement (位置和移動)
2. Newton's Laws (牛頓定律)
3. Moment of Force (力矩)
4. Work, Energy and Power (作功、能量和功率)
5. Momentum (動量)
6. Projectile Motion (拋體運動)
7. Circular Motion (圓周運動)
8. Gravitation (引力)

Section C – Wave Motion (波動)
1. Wave Propagation (波的推進)
2. Wave Phenomena (波動現象)
3. Reflection and Refraction of Light (光的反射及折射)
4. Lenses (透鏡)
5. Wave Nature of Light (光的波動特性)
6. Sound (聲音)

Section D – Electricity and Magnetism (電和磁)
1. Electrostatics (靜電學)
2. Electric Circuits (電路)
3. Domestic Electricity (家居用電)
4. Magnetic Field (磁場)
5. Electromagnetic Induction (電磁感應)
6. Alternating Current (交流電)

Section E – Radioactivity and Nuclear Energy (放射現象和核能)
1. Radiation and Radioactivity (輻射和放射現象)
2. Atomic Model (原子模型)
3. Nuclear Energy (核能)

Physics – Elective part (選修部分)

Elective 1 – Astronomy and Space Science (天文學和航天科學)
1. The universe seen in different scales (不同空間標度下的宇宙面貌)
2. Astronomy through history (天文學的發展史)
3. Orbital motions under gravity (重力下的軌道運動)
4. Stars and the universe (恒星和宇宙)

Elective 2 – Atomic World (原子世界)
1. Rutherford's atomic model (盧瑟福原子模型)
2. Photoelectric effect (光電效應)
3. Bohr's atomic model of hydrogen (玻爾的氫原子模型)
4. Particles or waves (粒子或波)
5. Probing into nano scale (窺探納米世界)

Elective 3 – Energy and Use of Energy (能量和能源的使用)
1. Electricity at home (家居用電)
2. Energy efficiency in building (建築的能源效率)
3. Energy efficiency in transportation (運輸業的能源效率)
4. Non-renewable energy sources (不可再生能源)
5. Renewable energy sources (可再生能源)

Elective 4 – Medical Physics (醫學物理學)
1. Making sense of the eye (眼的感官)
2. Making sense of the ear (耳的感官)
3. Medical imaging using non-ionizing radiation (非電離輻射醫學影像學)
4. Medical imaging using ionizing radiation (電離輻射醫學影像學)