<u>IB PHYSICS</u>: Newton and Kinematics Review

1. This question is about modelling the thermal processes involved when a person is running.

When running, a person generates *thermal energy* but maintains approximately constant *temperature*.

(a) Explain what *thermal energy* and *temperature* mean. Distinguish between the two concepts.

(4)

The following simple model may be used to estimate the rise in temperature of a runner assuming no thermal energy is lost.

A closed container holds 70 kg of water, representing the mass of the runner. The water is heated at a rate of 1200 W for 30 minutes. This represents the energy generation in the runner.

(b) (i) Show that the thermal energy generated by the heater is 2.2×10^6 J.

(2)

(ii) Calculate the temperature rise of the water, assuming no energy losses from the water. The specific heat capacity of water is 4200 J kg^{-1} K^{-1}.

(3)

(c) The temperature rise calculated in (b) would be dangerous for the runner. Outline **three** mechanisms, other than evaporation, by which the container in the model would transfer energy to its surroundings.

(6)

A further process by which energy is lost from the runner is the evaporation of sweat.

(d) (i) Describe, in terms of molecular behaviour, why evaporation causes cooling.

(3)

(ii) Percentage of generated energy lost by sweating: 50%
Specific latent heat of vaporization of sweat: 2.26×10 J kg^{-1}

Using the information above, and your answer to (b) (i), estimate the mass of sweat evaporated from the runner.

(3)

(iii) State and explain **two** factors that affect the rate of evaporation of sweat from the skin of the runner.

(4)
(Total 25 marks)

2. When a body is accelerating, the resultant force acting on it is equal to its

A. change of momentum.

B. rate of change of momentum.

C. acceleration per unit of mass.

D. rate of change of kinetic energy.

(1)

3. A small boat in still water is given an initial horizontal push to get it moving. The boat gradually slows down. Which of the following statements is true for the forces acting on the boat as it slows down?

A. There is a forward force that diminishes with time.

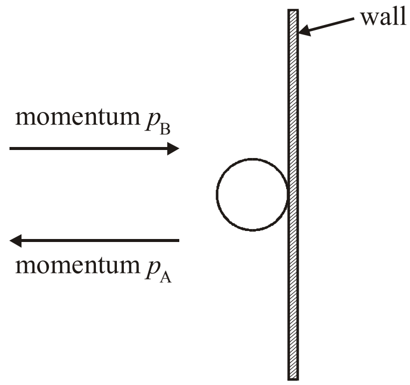
B. There is a backward force that diminishes with time.

C. There is a forward force and a backward force both of which diminish with time.

D. There is a forward force and a backward force that are always equal and opposite.

(1)

4. A sphere of mass m strikes a vertical wall and bounces off it, as shown below.



The magnitude of the momentum of the sphere just before impact is p_B and just after impact is p_A. The sphere is in contact with the wall for time t. The magnitude of the average force exerted by the wall on the sphere is

A. $\frac{(p_B - p_A)}{t}$.

B. $\frac{(p_B + p_A)}{t}$.

C. $\frac{(p_B - p_A)}{mt}$.

D. $\frac{(p_B + p_A)}{mt}$.

1)

5. A ball, initially at rest, takes time t to fall through a vertical distance h. If air resistance is ignored, the time taken for the ball to fall from rest through a vertical distance $9h$ is

A. $3t$.

B. $5t$.

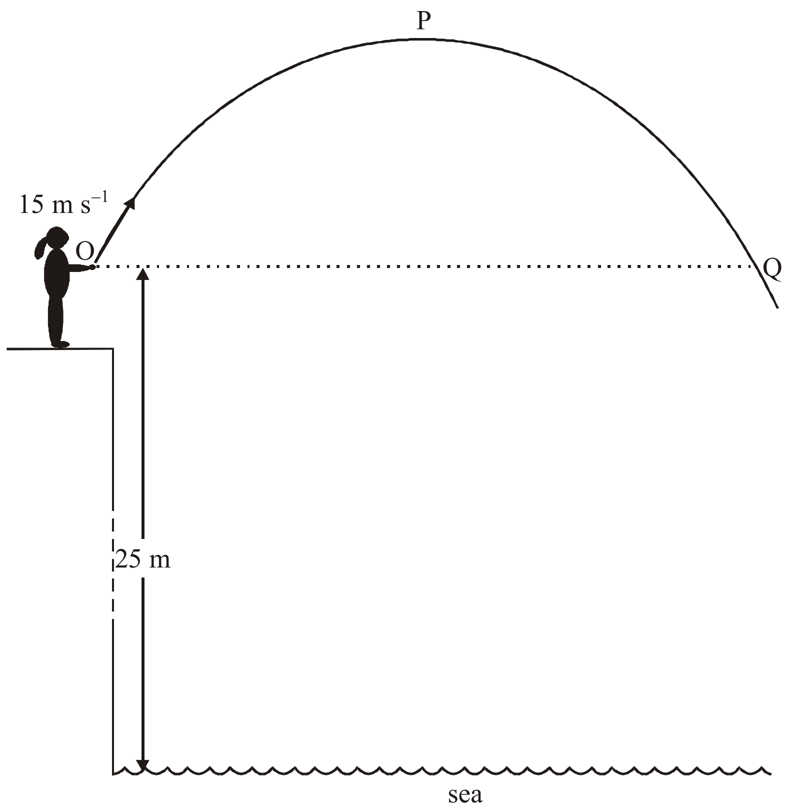
C. $9t$.

D. $10t$.

(1)

6. This question is about projectile motion and the use of an energy argument to find the speed with which a thrown stone lands in the sea.

Christina stands close to the edge of a vertical cliff and throws a stone. The diagram below *(not drawn to scale)* shows part of the trajectory of the stone. Air resistance is negligible.



Point P on the diagram is the highest point reached by the stone and point Q is at the same height above sea level as point O.

(a) At point P on the diagram above draw arrows to represent

(i) the acceleration of the stone (label this A). **(1)**

(ii) the velocity of the stone (label this V). (1)

The stone leaves Christina's hand (point O) at a speed of 15 m s^{-1} in the direction shown. Her hand is at a height of 25 m above sea level. The mass of the stone is 160 g. The acceleration due to gravity $g = 10$ m s^{-2}.

(b) (i) Calculate the kinetic energy of the stone immediately after it leaves Christina's hand. **(1)**

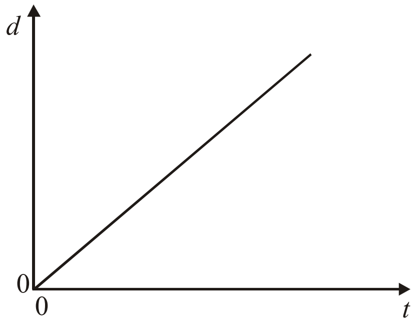
(ii) State the value of the kinetic energy at point Q. **(1)**

(iii) Calculate the loss in potential energy of the stone in falling from point Q to hitting the sea. **(1)**

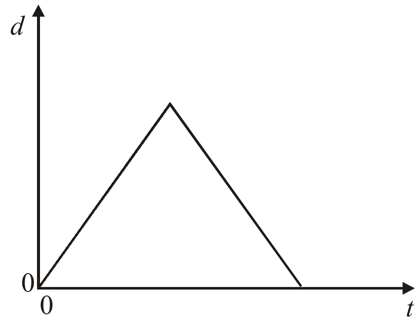
(iv) Determine the speed with which the stone hits the sea. **(2)**

7. An athlete runs round a circular track at constant speed. Which **one** of the following graphs best represents the variation with time *t* of the magnitude *d* of the **displacement** of the athlete from the starting position during one lap of the track?

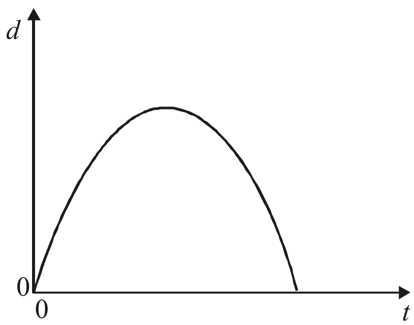
A.



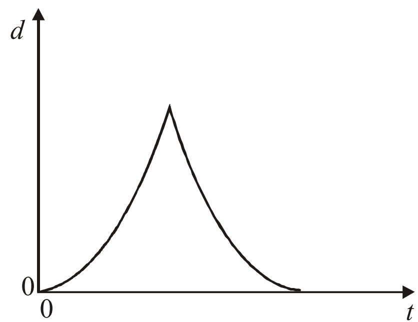
B.



C.

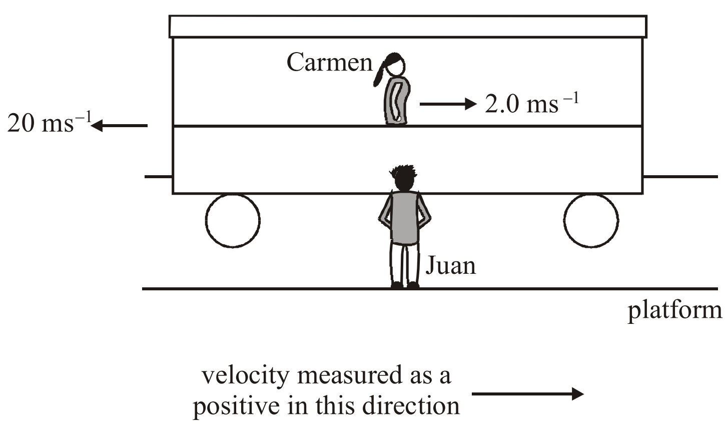


D.



(1)

8. Juan is standing on the platform at a railway station. A train passes through the station with speed 20 m s^{-1} in the direction shown measured relative to the platform. Carmen is walking along one of the carriages of the train with a speed of 2.0 m s^{-1} measured relative to the carriage in the direction shown. Velocity is measured as positive in the direction shown on the diagram.



The velocity of Carmen relative to Juan is

A. –22 m s^{-1}.

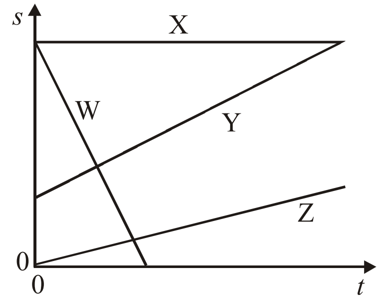
B. –18 m s^{-1}.

C. +18 m s^{-1}.

D. +22 m s^{-1}.

(1)

9. Four cars W, X, Y and Z are on a straight road. The graph below shows the variation with time t of the distance s of each car from a fixed point.



Which car has the greatest speed?

A. W

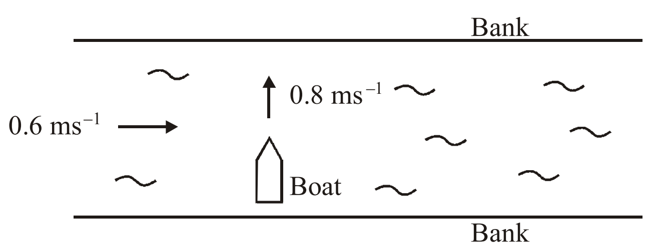
B. X

C. Y

D. Z

(1)

10. The diagram below shows a boat that is about to cross a river in a direction perpendicular to the bank at a speed of 0.8 ms^{-1}. The current flows at 0.6 ms^{-1} in the direction shown.



The magnitude of the displacement of the boat 5 seconds after leaving the bank is

A. 3 m.

B. 4 m.

C. 5 m.

D. 7 m.

(1)

11. The kWh is equal to

A. 1.0×10^3 J.

B. 3.6×10^3 J.

C. 6.0×10^4 J.

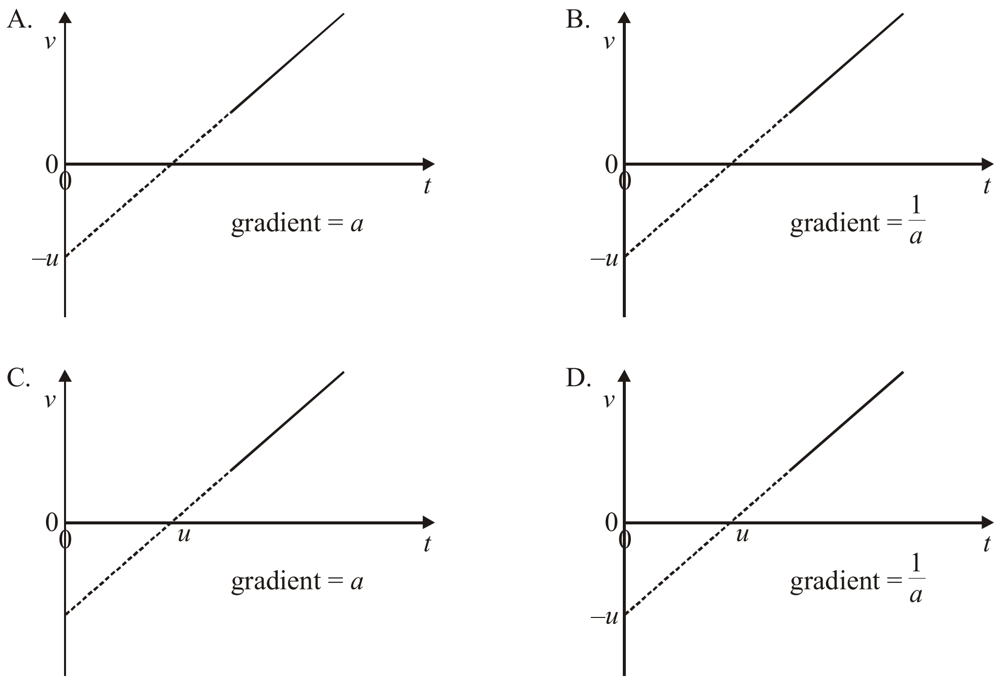
D. 3.6×10^6 J.

12. The variation with time t of the speed v of an object is given by the expression

$$v = u + at$$

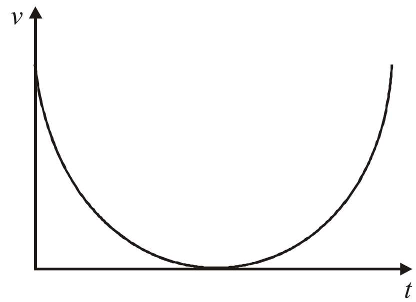
where u and a are constants.

A graph of the variation with time t of speed v is plotted. Which **one** of the following correctly shows how the constants may be determined from this graph?



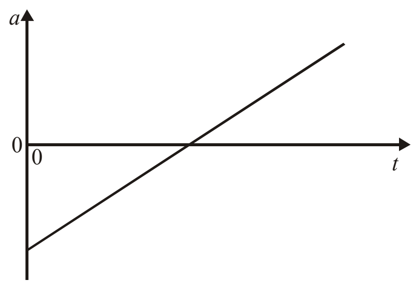
(1)

13. The graph shows the variation with time t of the velocity v of an object.

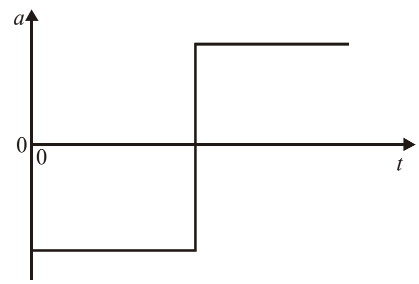


Which **one** of the following graphs best represents the variation with time t of the acceleration a of the object?

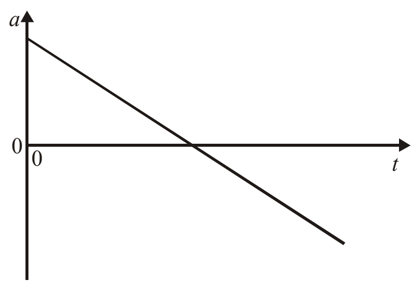
A.



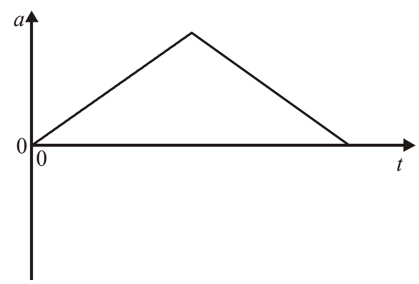
B.



C.



D.



(1)

14. This question is about conservation of momentum and conservation of energy.

(a) State Newton's third law.

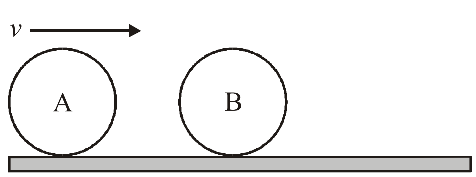
(1)

(b) State the law of conservation of momentum.

(2)

The diagram below shows two identical balls A and B on a horizontal surface. Ball B is at rest and ball A is moving with speed V along a line joining the centres of the balls. The mass of each ball is M.

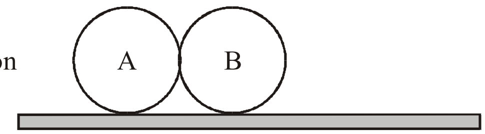
Before collision



During the collision of the balls, the magnitude of the force that ball A exerts on ball B is F_{AB} and the magnitude of the force that ball B exerts on ball A is F_{BA}.

(c) On the diagram below, add labelled arrows to represent the magnitude and direction of the forces F_{AB} and F_{BA}.

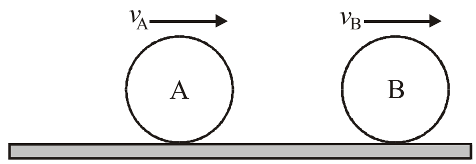
During the collision



(3)

The balls are in contact for a time Δt. After the collision, the speed of ball A is $+v_A$ and the speed of ball B is $+v_B$ in the directions shown.

After the collision



As a result of the collision, there is a change in momentum of ball A and of ball B.

(d) Use Newton's second law of motion to deduce an expression relating the forces acting during the collision to the change in momentum of

(i) ball B.

(2)

(ii) ball A.

(2)

(e) Apply Newton's third law and your answers to (d), to deduce that the change in momentum of the system (ball A and ball B) as a result of this collision, is zero.

(4)

(f) Deduce, that if kinetic energy is conserved in the collision, then after the collision, ball A will come to rest and ball B will move with speed V.

(3)
(Total 17 marks)