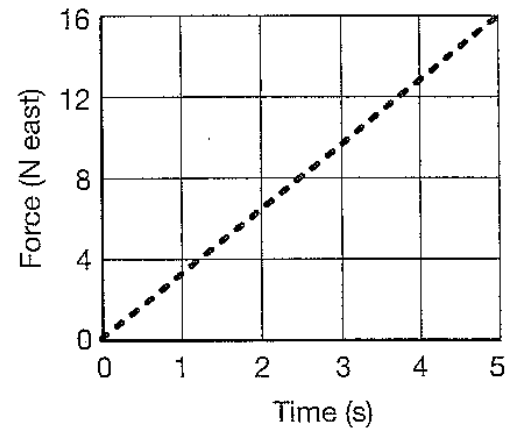
2.2.11 Determine the impulse due to a time-varying force by interpreting a force-time graph. © IBO 2007

2.2.11.1 The graph shows how the force acting on a 0.4 kg object changes with time.

(a) Calculate the acceleration of the object at $t = 5$ s.



(b) Calculate its acceleration at 2.0 s.

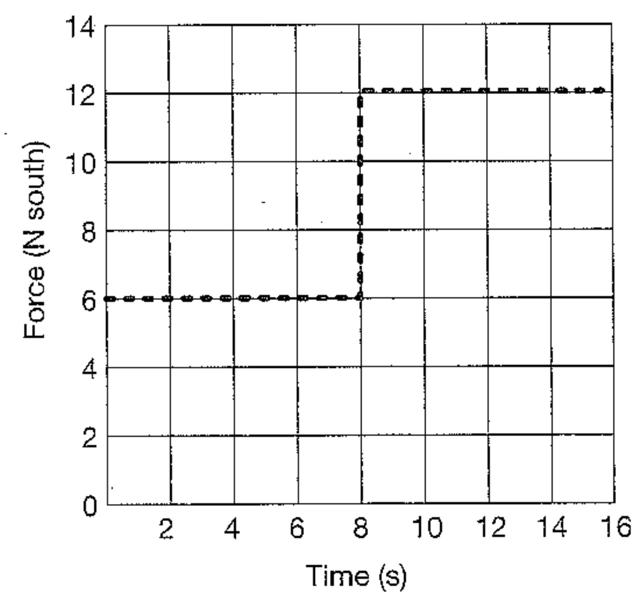
(c) Calculate the object's change in speed during the 5 s.

(d) If its initial velocity was 22 m s^{-1} west, calculate its final velocity.

2.2.11.2 Some hammers have heads made of steel. Some have rubber heads. Steel hammers are used to hammer nails while rubber hammers are for laying paving stones. Explain how their different construction enhances these uses.

2.2.11.3 The graph shows how the force acting on a 3.0 kg object changed over a period of time. The object was initially at rest.

(a) Use the graph to find the change in momentum of the object during the first 8 s.



(b) Calculate the velocity of the object after 8 s.

(c) Calculate the total impulse applied to the object.

(d) Calculate the final velocity of the object.

(e) What constant force acting on the object for 16 s would cause the same impulse?

2.2.11.4 The graph shows how the force on a mass of 2.5 kg changes over time. Calculate the:

(a) Impulse applied in the first 2.5 s.

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(b) Mass's change in velocity at 2.5 s.

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(c) Impulse applied in the first 5.0 s.

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(d) Change in velocity at 5.0 s.

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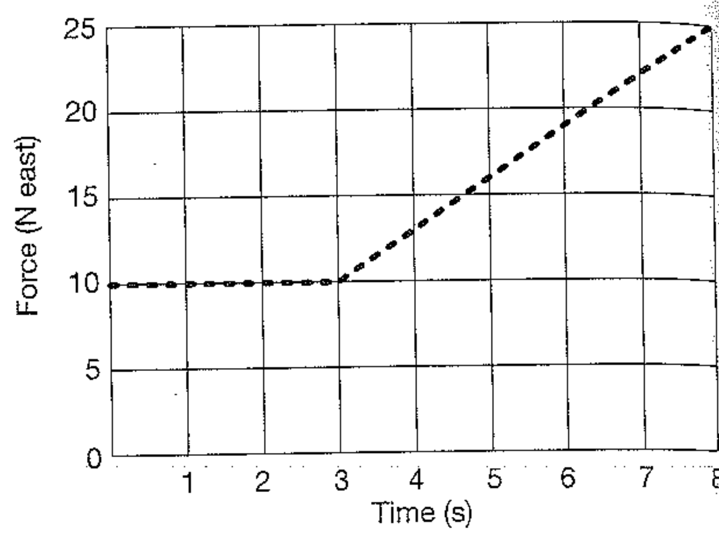

(e) (i) Mass's final velocity if its initial velocity was zero.

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(ii) Mass's final velocity if its initial velocity was 12 m s^{-1} east.

....

(iii) Mass's final velocity if its initial velocity was 18 m s^{-1} west.

....

2.2.11.5 The graph shows the force-time relationship for a 50 g golf ball being hit by a club.

(a) Identify the maximum force applied to the golf ball.

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(b) Calculate the average force applied to the ball.

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(c) Calculate the total impulse applied.

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(d) Calculate the speed of the ball just after being hit.

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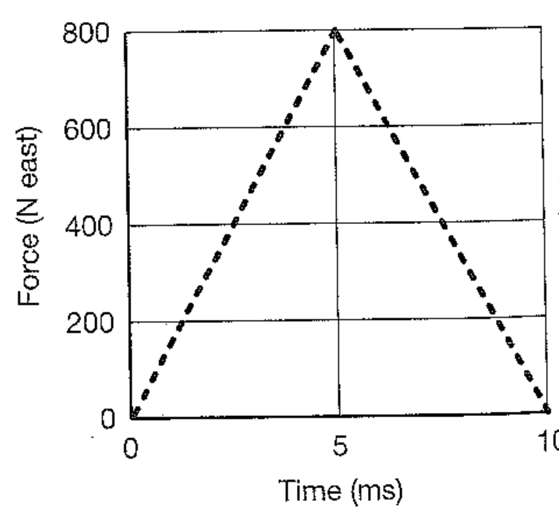

2.2.11.6 A 125 g cricket ball slams into the wicket-keeper's gloves at 100 kph. The keeper takes 0.5 s to catch the ball.

(a) Calculate the impulse the ball applies to the gloves. ....

(b) Calculate the impulse the gloves apply to the ball. ....

(c) Calculate the average force the ball applies to the gloves. ....

(d) Calculate the average force the gloves apply to the ball. ....

(e) What law are you using to answer Questions (b) and (d)? ....

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2.2.11.7 A 100 g toy car moving at 3.0 m s^{-1} hits a wall at right angles and rebounds at 2.8 m s^{-1}. The collision with the wall takes 0.25 s. (Remember, velocity is a vector quantity.)

(a) Calculate the impulse applied to the wall by the car.

(b) Calculate the impulse applied to the car by the wall.

(c) Calculate the average force involved in this collision.

2.2.11.8 A passenger in a car that has a synthetic plastic bumper bar will usually suffer less injury than a passenger in a car with a solid, chromed metal bumper bar. Explain how this is possible.

2.2.11.9 A model of an 80.0 kg man and one of a 20 kg child were placed in an 800 kg car and secured with seatbelts. The car was moving at 60 kph when it crashed into a brick wall.

(a) Explain what would happen to the models during the collision.

(b) Identify the law of physics you are using in your answer to (a).

(c) Explain how the effect on the models would differ if the front section of the car was specially designed to concertina on impact.

(d) If the collision took 0.2 s, calculate the average force exerted on each model by its seatbelt.

(e) Calculate the speed at which each model would be thrown forwards.

(f) Assess if it would be possible for a mother to nurse a child and protect it from a collision like this.

2.2.12.3 Calculate the missing values in the table.

Momentum change	Impulse causing momentum change	Force if each change took 4 s
(a) From 10.0 kg m s^{-1} W to 15 kg m s^{-1} W.		
(b) From 0.6 kg m s^{-1} W to 15 kg m s^{-1} E.		
(c) From 12.0 kg m s^{-1} S to 15 kg m s^{-1} N.		
(d) From 10.0 kg m s^{-1} N to 15 kg m s^{-1} N.		
(e) From 10.0 kg m s^{-1} W to 2.5 kg m s^{-1} W.		

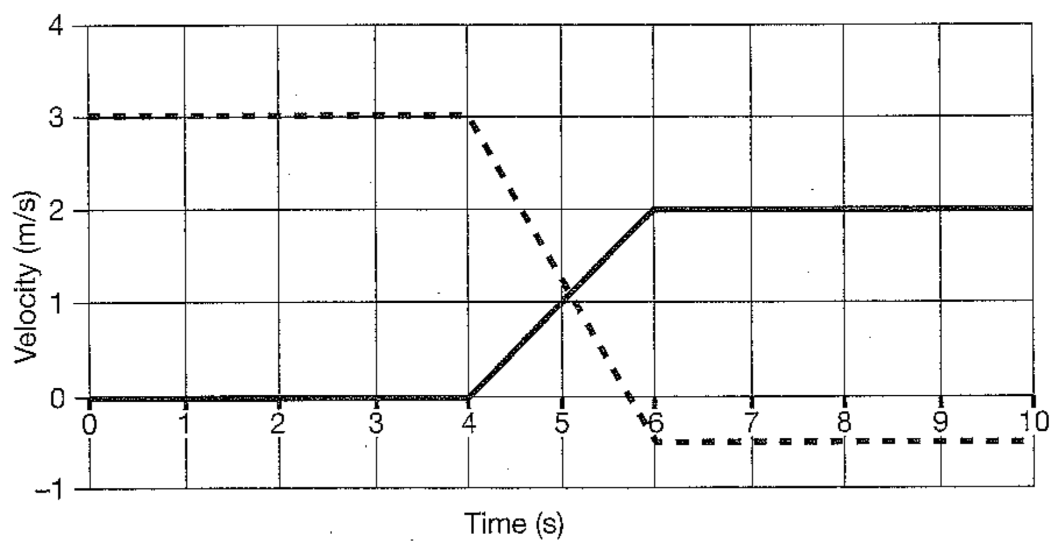
2.2.12.4 A toy car of mass 4.0 kg is struck horizontally by another car causing it to accelerate from 4.0 m s^{-1} to 10.0 m s^{-1} in 0.1 s. If the car was on a frictionless surface, calculate:

(a) Its change in momentum. ....

(b) The impulse applied to it. ....

(c) The average force applied to it. ....

2.2.12.5 A train carriage X of mass 400 kg moving at 3.0 m s^{-1} collides with another train carriage Y of mass 700 kg initially at rest. The graph shows how the velocities of the carriages change before, during and after the collision.



(a) Using the information in the graph, show that momentum is conserved in this collision.

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(b) Using the information in the graph, determine whether or not kinetic energy is conserved.

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(c) Calculate the magnitude of the average force on carriage X during the collision.

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2.2.12.6 A force of 18 N E acts on a 6.0 kg object for 4.5 s. The object was initially moving west at 15 m s^{-1}.

(a) Calculate the impulse of the force.

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(b) Calculate the change in momentum of the object.

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(c) Calculate the final momentum of the object.

....

(d) Calculate the final velocity of the object.

....

Answer Questions 2.2.12.7 and 2.2.12.8 on your own paper.

2.2.12.7 A car of mass 800 kg accelerates from 12 m s^{-1} to 40 m s^{-1} in 7.0 s. Calculate:

(a) The impulse acting on the car.

(b) The average force on the car.

(c) The momentum of the car if the force acts on it for another 5 s.

2.2.12.8 As a result of being hit from behind by a toy truck, a 500 g toy car, initially at rest, rolls 12.0 m across a floor that applies a constant retarding force of 1.2 N to it. The car stops after 2.0 s.

(a) Calculate the instantaneous speed of the car just after being hit.

(b) Calculate the momentum of the car just after being hit.

(c) Calculate the acceleration of the car as a result of the collision.

(d) Calculate the force applied to the car by the collision.

2.2.12.9 A force of 125 N must act to the left on a 6.0 kg toy truck. A second force of 45 N acts on the same truck to the right. As a result, the speed of the truck changes by 8.0 m s^{-1}. Calculate how long it takes for this speed change to occur.

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