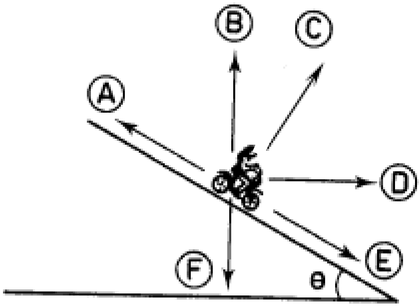
Multiple Choice



Example 1 (1976 Question 9, 1 mark)

A cyclist is accelerating downhill with his brakes off. Which arrow (A – F) **best** represents the direction of the force of the road on the bicycle?

The cyclist now brakes so that his speed is constant.

Example 2 (1976 Question 10, 1 mark)

The mass of the cyclist is *m*; the road makes an angle θ with the horizontal. The magnitude of the vector sum of all forces acting on the cyclist is

A. mg

B. $mg \cos \theta$

C. $mg \sin \theta$

D. zero

Example 3 (1976 Question 11, 1 mark)

Which arrow (A – F) now **best** represents the direction of the force of the road on the bicycle?

Example 4 (1981 Question 5, 1 mark)

A man of mass *m* is suspended from a parachute of mass *M* and descends at a constant speed. What is the net force acting on the man?

A mg

B $mg + Mg$

C $mg - Mg$

D zero

Example 5 (1981 Question 6, 1 mark)

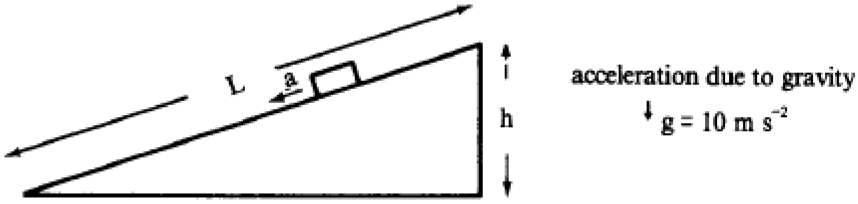
A girl starts to run in a northerly direction across a floor. The frictional force of the floor on her shoes is

A in a northerly direction: it is the friction between the floor and her shoes which allows her to travel in that direction.

B in a southerly direction: friction always acts to oppose motion.

C virtually zero, because the girl is running and not sliding across the floor.

D zero, because action and reaction forces are equal and opposite.



For a block sliding down the frictionless inclined plane of height *h* metre and length *L* metre, it can be shown that the acceleration, *a* ms^{-2} is given by

$a \propto \frac{h}{L}$ i.e. $a = k\frac{h}{L}$ where *k* is a constant

Example 6 (1981 Question 7, 1 mark)

What is the numerical value of the constant *k*?

A 1

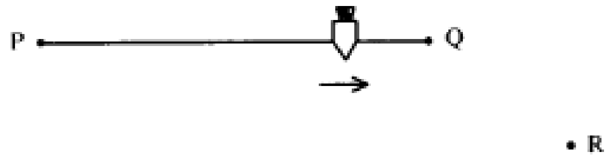
B 5

C 10

D 20

E 100

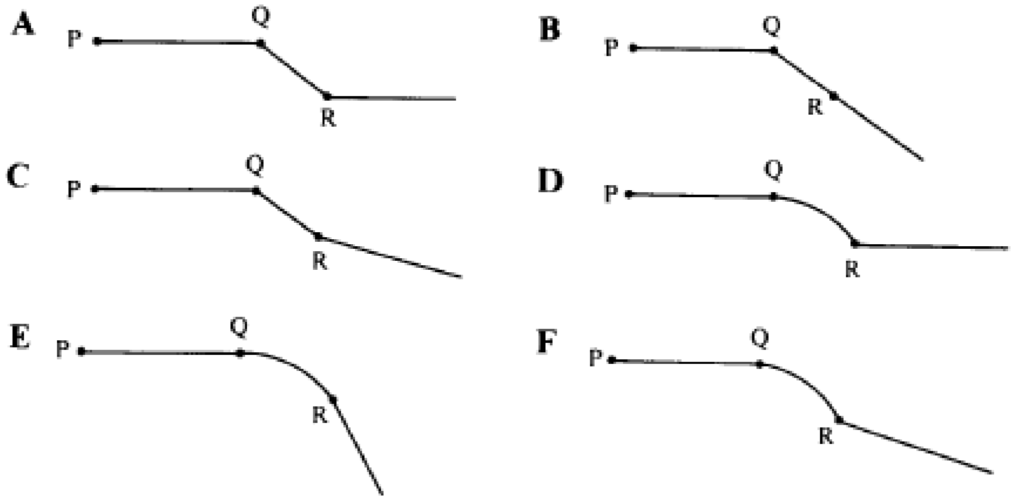
A rocket is drifting sideways from *P* to *Q* in outer space. It is not subject to any outside forces.



When the rocket reaches *Q,* its engine is fired to produce a constant thrust at right angles to *PQ*. The engine is turned off again when it reaches *R*.

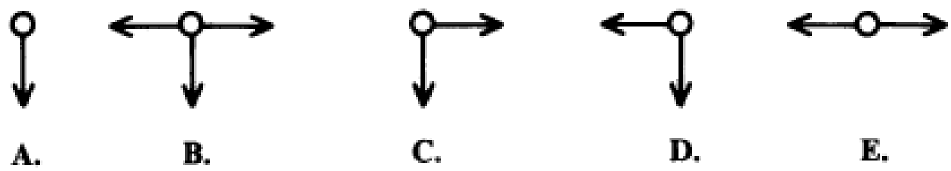
Example 7 (1983 Question 4, 1 mark)

Which of the following (**A, B, C, D, E, or F**) best represents the path of the rocket?



Example 8 (1984 Question 23, 1 mark)

A golf ball travels a distance of 250 m through the air as the result of a very powerful hit. **If it is travelling to the right**, which of the diagrams below gives the best representation of the forces acting on it when it is at the highest point of its flight, if air resistance needs to be considered.



A steel ball is dropped vertically on to a steel bench-top. *W* is the weight force acting on the ball and F_C is the contact force exerted on the ball by the bench at the instant of rebound when the ball is at rest.

Example 9 (1984 Question 24, 1 mark)

Which **one or more** of the following statements about *W* and F_C are correct?

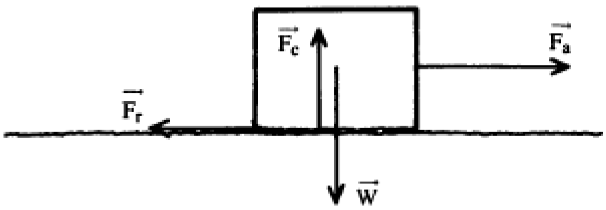
A *W* and F_C form an action-reaction pair and so are equal in magnitude.

B The ball is instantaneously at rest, so *W* and F_C cancel exactly to provide the necessary zero resultant force.

C the ball is accelerating upwards, so F_C must be greater than *W*.

D F_C may be greater or less in magnitude than *W* depending on whether the collision is elastic or inelastic.

Newton's third law of motion may be stated as follows: 'To every action there is an equal and opposite reaction, or the mutual reactions of two bodies upon each other are always equal and directed in contrary directions'.



The figure above shows a block being pulled along a rough surface at constant velocity. $\vec{F_a}$ is the applied force on the block, $\vec{F_r}$ the friction force between the block and the surface, $\vec{W}$ the weight force on the block and $\vec{F_c}$ the normal contact force exerted by the surface on the block.

Example 10 (1985 Question 17, 1 mark)

Which pair of forces (**A – D**) in this situation are action-reaction pairs in the sense of Newton's third law?

A $\vec{W}$ and the gravitational force exerted by the block on the earth.

B $\vec{F_a}$ and $\vec{F_r}$.

C $\vec{W}$ and $\vec{F_c}$.

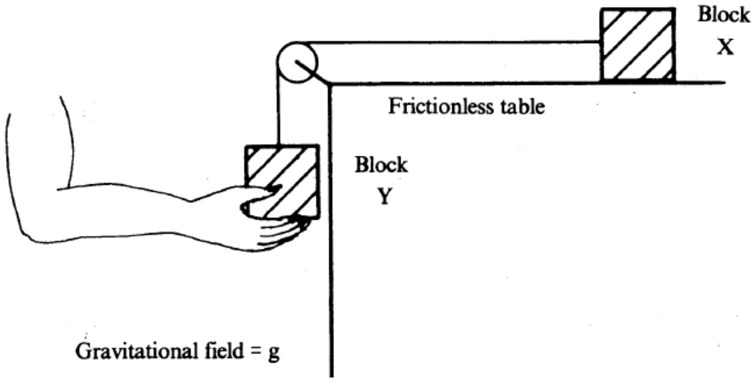
D none of these.

A recent Transport Accident Commission television advertisement explains the significant difference between car stopping distances when travelling at 30 km h^{-1} and 60 km h^{-1}.

Example 11 (2000 Question 10, 2 marks)

The stopping distance, from when the brakes are applied, for a car travelling at 30 km h^{-1} is 10 m. Which **one** (**A – D**) is the best estimate of the stopping distance for the same car, under the same braking, but travelling at 60 km h^{-1}?

A. 20 m **B.** 30 m **C.** 40 m **D.** 90 m



Two blocks, each of mass m, are connected by means of a string which passes over a frictionless pulley. One is at rest on a frictionless table; the other is held at rest in the position shown.

Example 12 (**1981 Question 9, 1 mark)**

What is the force of the string on Block X?

A. zero

B. mg/2

C. mg

D. 2mg

Example 13 (**1981 Question 10, 1 mark)**

Block Y is now released and the blocks move. What will then be the net force on Y?

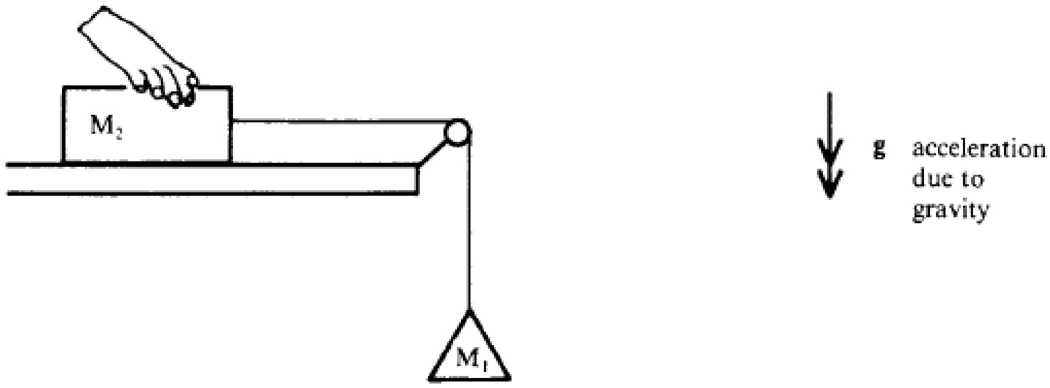
A. zero

B. mg/2

C. mg

D. 2mg

A block of mass M_2 is held at rest on a horizontal frictionless table. A string is attached to a mass M_1 over a light frictionless pulley as shown below.



Example 14 (**1983 Question 7, 1 mark)**

If the block is then released, which of the statements below best describes the subsequent state of the block?

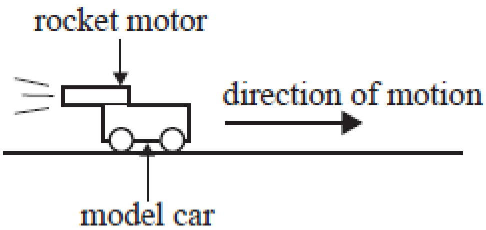
A The block starts to move with an acceleration $\frac{M_1 + M_2}{M_2}g$

B The block starts to move with an acceleration $\frac{M_1}{M_1 + M_2}g$

C The block starts to move with an acceleration g

D The direction of the motion depends on whether M_2 is greater or less than M_1.

A model car of mass 2.0 kg is propelled from rest by a rocket motor that applies a constant horizontal force of 4.0 N, as shown below. Assume that friction is negligible.



Example 15 (**2017 Question 7, 1 mark)**

Which one of the following best gives the magnitude of the acceleration of the model car?

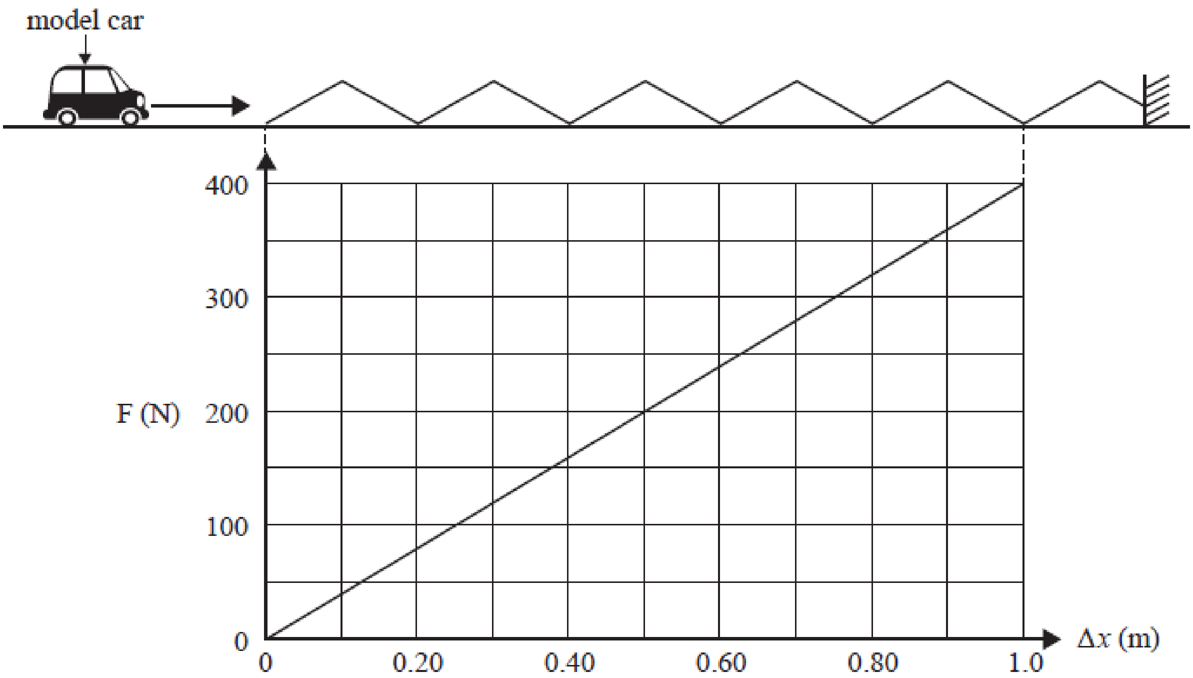
A. 0.50 m s^{-2}

B. 1.0 m s^{-2}

C. 2.0 m s^{-2}

D. 4.0 m s^{-2}

A model car is on a track and moving to the right. It collides with and compresses a spring that is considered ideal, as shown in the diagram below.
The car compresses the spring to 0.50 m when the car comes to rest. The force–distance graph for the spring is also shown below.
Assume that friction is negligible.



Example 16 (**2017 Question 12, 1 mark)**

Based on the graph above, what is the best estimate of the spring constant, *k*?

A. 100 N m^{-1}

B. 200 N m^{-1}

C. 400 N m^{-1}

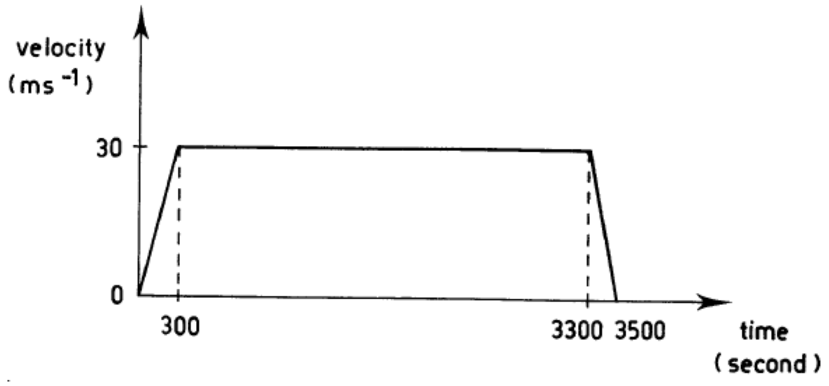
D. 800 N m^{-1}

Extended questions

Example 17 (1973 Question 8, 1 mark)

A car has a maximum acceleration of 3.0 m s^{-2}. What would its maximum acceleration be while towing a car twice its own mass?

A train accelerates from rest at one station and travels to another station. The velocity-time for the train is given below. The mass of the train is 5.0 x 10^5 kg. Assume that a constant frictional resistance of 1.5 x 10^4 N acts on the train throughout its journey.



Example 18 (1976 Question 1, 1 mark)

Calculate the distance between the two stations.

Example 19 (1976 Question 2, 1 mark)

Calculate the net force acting on the train during the first 300 seconds.

Example 20 (1976 Question 3, 1 mark)

Calculate the force exerted by the engine on the train during the first 300 seconds.

Example 21 (1976 Question 4, 1 mark)

Calculate the power in kilowatt at which the engine works during the period of constant velocity.

A car of mass 800 kg is towed along a straight road so that its velocity changes uniformly from 10 m s^{-1} to 20 m s^{-1} in a distance of 200 m. The frictional force is constant at 500 N.

Example 22 (1977 Question 1, 1 mark)

Calculate the acceleration of the car.

Example 23 (1977 Question 2, 1 mark)

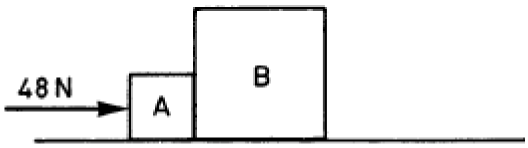
What is the magnitude of the net force on the car during this 200 m?

Example 24 (1977 Question 3, 1 mark)

What is the magnitude of the force exerted on the car by the towing vehicle?

Example 25 (1977 Question 4, 1 mark)

When the speed of 20 m s^{-1} is reached, the towing force is adjusted so that the car now moves at constant velocity. What is now the magnitude of the towing force?



Two masses **A** and **B** are accelerated together along a smooth surface by a force of 48 N, as shown above. The acceleration of **A** and **B** is 4.0 m s^{-2}.
The mass of **A** is 4.0 kg

Example 26 (1979 Question 8, 1 mark)

What is the mass of **B**?

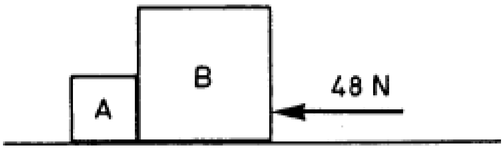
Example 27 (1979 Question 9, 1 mark)

What is the magnitude of the force exerted by **A** on **B**?

Example 28 (1979 Question 10, 1 mark)

What is the magnitude of the force exerted by **B** on **A**?

The bodies are now accelerated together along a smooth surface in the opposite direction by a force of 48 N, as shown below.



Example 29 (1979 Question 11, 1 mark)

What now is the magnitude of the force exerted by **B** on **A**?

A 1.0 kg mass is suspended from a spring balance which is attached to the roof of a lift. The balance is graduated in newton and reads 10 N when the lift is stationary.

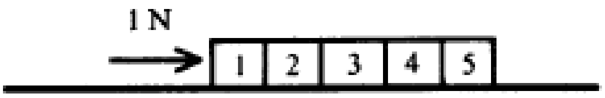
Example 30 (1980 Question 14, 1 mark)

What is the reading of the spring balance when the lift moves up with an acceleration of 2.0 m s^{-2}?

Example 31 (1980 Question 15, 1 mark)

What is the reading of the spring balance when the lift moves up with an upward constant velocity of 2.0 m s^{-1}?

Five identical blocks each of mass 1.0 kg are on a smooth, horizontal table.
A constant force of 1 N acts on the first block as shown in the figure below.

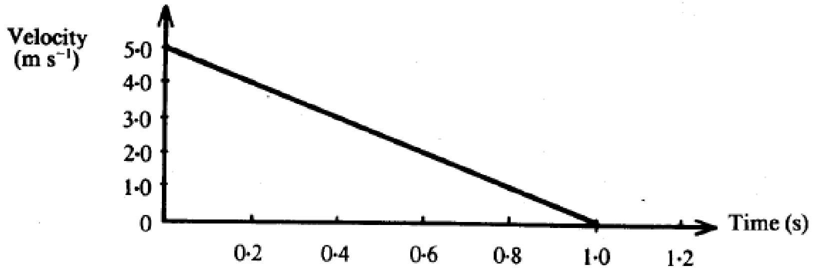


Example 32 (1985 Question 14, 1 mark)

What force does block 4 exert on block 5?

Example 33 (1985 Question 15, 1 mark)

What force does block 3 exert on block 4?



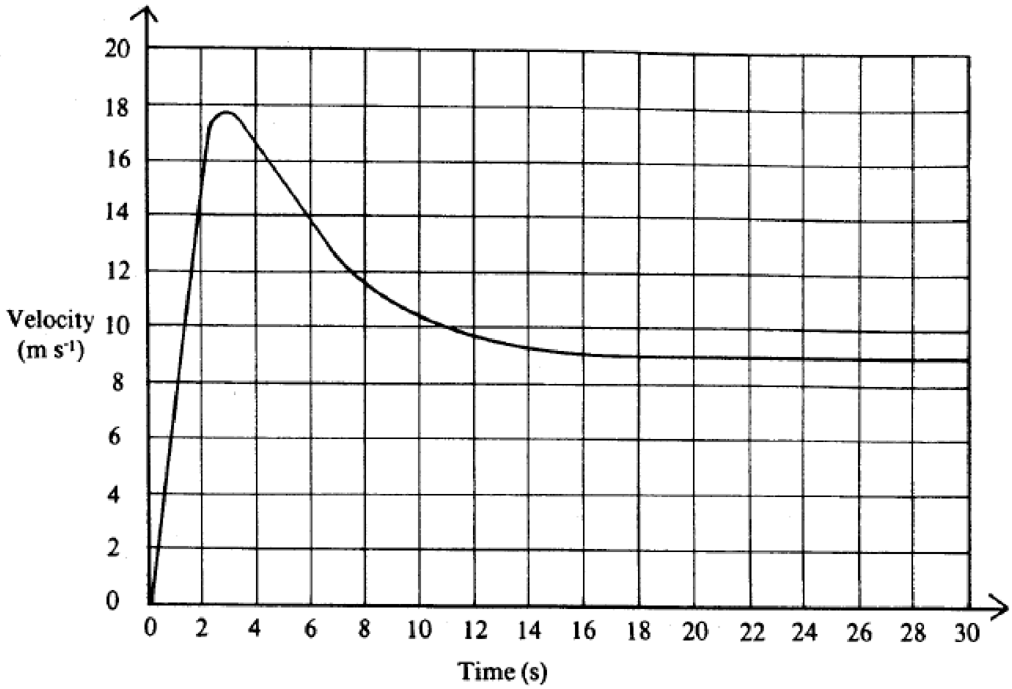
The graph above gives the velocity-time relationship for a block of mass 4.0 kg which slides across a rough, horizontal floor, coming to rest after 1.0 s.

Example 34 (1986 Question 1, 1 mark)

What is the magnitude of the frictional force of the floor on the block?

Example 35 (1986 Question 2, 1 mark)

What is the magnitude of the frictional force of the block on the floor?



The diagram above shows a velocity-time graph of the motion of a parachutist of mass 100 kg, when he jumps from an aircraft. After jumping, he waits for 2.0 seconds before pulling the ripcord, opening his parachute. (Take g: 10 m s^{-2})

Example 36 (1987 Question 5, 1 mark)

What is his acceleration at time t =1.0 s?

Example 37 (1987 Question 6, 1 mark)

What is the value of the ratio: $\frac{\text{Force of gravity on the parachutist at t = 1.0 s}}{\text{Force of gravity on the parachutist at t = 6.0 s}}$?

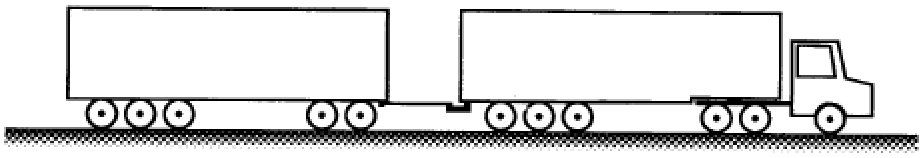
Example 38 (1987 Question 7, 1 mark)

What is the resultant force on the parachutist at t =1.0s?

Example 39 (1987 Question 8, 1 mark)

What is the resultant force on the parachutist at t = 20.0 s?

A road train consists of a large truck towing a trailer, as shown below. The truck and the trailer have a mass of 2.0×10^4 kg each. When moving along a level road, the truck and the trailer experience a constant retarding force of 2.5×10^3 N each.



Example 40 (1991 Question 4, 1 mark)

If the driving force on the road train when it is accelerating is 3.9×10^4 N, what is the magnitude of the acceleration?

Example 41 (1991 Question 5, 1 mark)

What is the tension force in the coupling between the truck and trailer when the road train is moving at constant speed?

When the road train is travelling along a straight, level road at 20 m s^{-1} the truck is put into neutral gear and the train allowed to roll to a stop.

Example 42 (1991 Question 6, 1 mark)

How far will it travel before coming to rest?

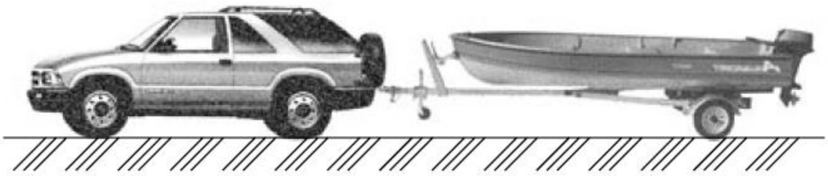
A car is tested on a straight level track on a day when there is no wind. When the car reaches 20.0 m s^{-1} the driver puts the car into neutral gear. The wheels are no longer driving the car, and it gradually slows due to frictional forces. Measurements show that the car's speed decreases uniformly from 20.0 m s^{-1} to 18.0 m s^{-1} in 4.0 s. The mass of the car is 1100 kg.

Example 43 (1996 Question 5, 1 mark)

Calculate the magnitude of the net force on the car when it is slowing down.

Example 44 (1996 Question 6, 1 mark)

Calculate the power required at the wheels of the car for it to be driven at a constant speed of 20.0 m s^{-1} on the straight level track.



The figure shows a car of mass 1600 kg towing a boat and trailer of mass 1200 kg.
The driver changes the engine power to maintain a constant speed of 72 km h^{-1} on a straight road.
The total retarding force on the car is 1400 N and on the boat and trailer 1200 N.

Example 45 (2004 Question 1, 2 marks)

Calculate the driving force exerted by the car at this speed.

To overtake another car the driver accelerates at a constant rate of 1.20 m s^{-2} from 72 km h^{-1} until reaching 108 km h^{-1}

Example 46 (2004 Question 2, 3 marks)

Calculate the distance covered during this acceleration.

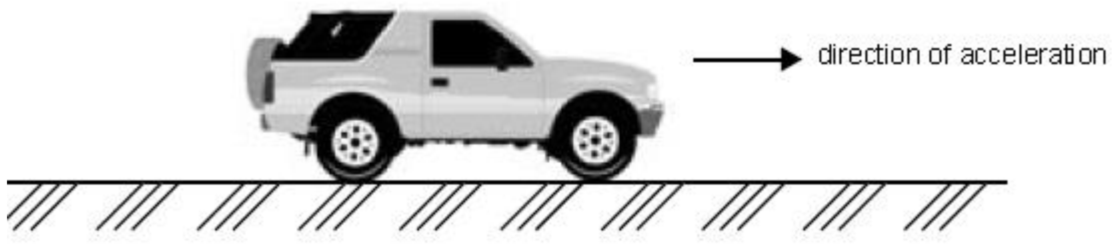
Example 47 (2004 Question 3, 3 marks)

Calculate the tension in the coupling between the car and trailer during the acceleration. (Assume the same retarding forces of 1400 N and 1200 N respectively.)

Two students are discussing the forces on the tyres of a car. Both agree that there must be a friction force acting on the tyres of a car. The first student claims that the friction force acts to oppose the motion of the car and slow it down, for example, when braking. The second student claims that friction acts in the direction of motion as a driving force to speed the car up when accelerating.

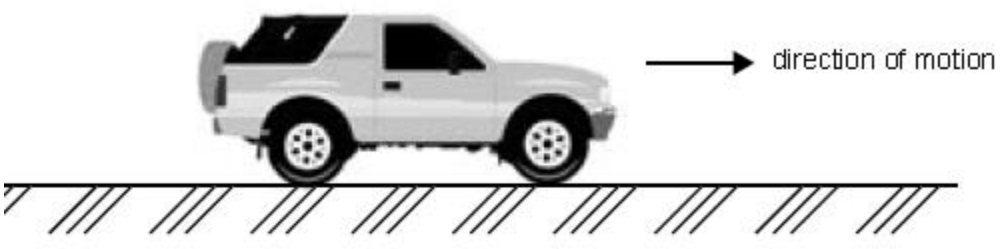
Example 48 (2004 Question 8, 3 marks)

On the diagram of the front-wheel drive car in the figure below, clearly show all the forces acting **on the tyres** of the car **when it is accelerating** forwards in a straight line. Use arrows for the force vectors to show both the **magnitude** and **point of action** of the different forces.

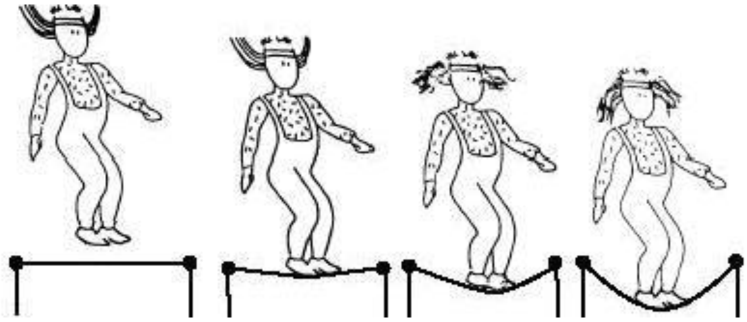


Example 49 (2004 Question 9, 2 marks)

On the diagram of the same car below clearly show all the forces acting **on the tyres** of the car **when it is braking** in a straight line. Use arrows for the force vectors to show both the **magnitude** and **point of action** of the different forces.



Anna is jumping on a trampoline. The figure below shows Anna at successive stages of her downward motion.



a **b** **c** **d**

Figure c shows Anna at a time when she is **travelling downwards** and **slowing down**.

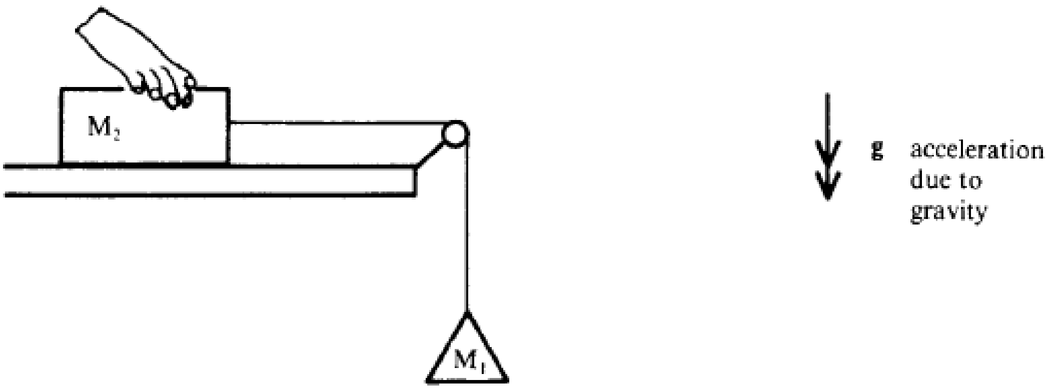
Example 50 (1999 Question 6, 2 marks)

What is the direction of Anna's acceleration at the time shown in **Figure 4c**? **Explain** your answer.

Example 51 (1999 Question 7, 3 marks)

On **Figure c** draw arrows that show the **two individual** forces acting on Anna at this instant. **Label each arrow** with the name of the force and indicate the **relative magnitudes** of the forces by the **lengths** of the arrows you draw.

A block of mass M_2 is held at rest on a horizontal frictionless table. A string is attached to a mass M_1 over a light frictionless pulley as shown below.



Example 52 (**1983 Question 6, 1 mark)**

What is the tension in the string while the block is being held?

A car of mass 1300 kg has a caravan of mass 900 kg attached to it. The car and caravan move off from rest. They have an initial acceleration of 1.25 m s^{-2}.

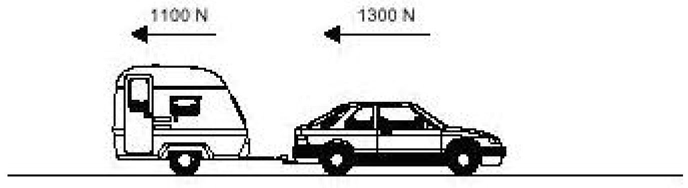
Example 53 (2000 Question 11, 2 marks)

What is the net force acting on the total system of car and caravan as it moves off from rest?

Example 54 (2000 Question 12, 3 marks)

What is the tension in the coupling between the car and the caravan as they start to accelerate?

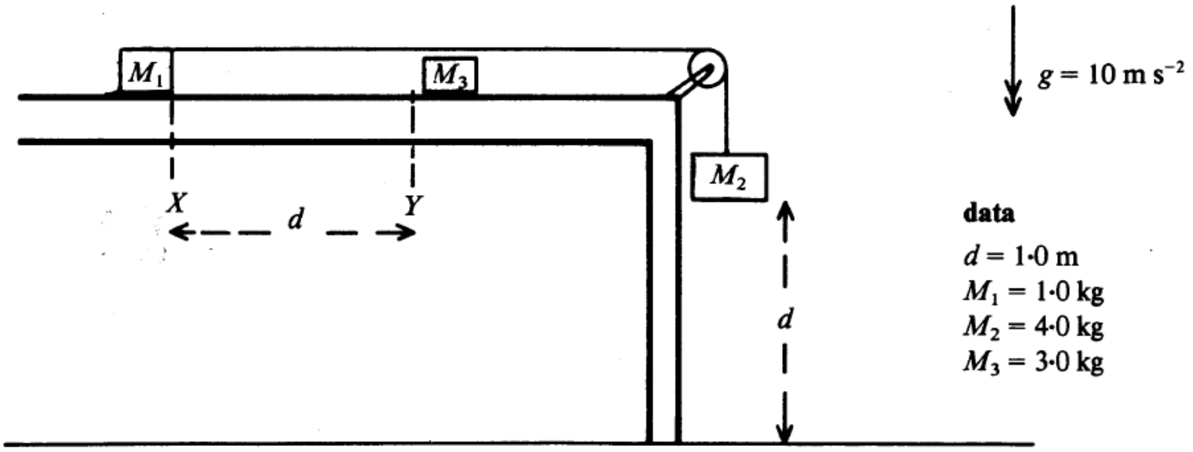
After some time the car reaches a speed of 100 km h^{-1}, and the driver adjusts the engine power to maintain this constant speed. At this speed, the total retarding force on the car is 1300 N, and on the caravan 1100 N.



Example 55 (2000 Question 13, 2 marks)

What **driving** force is being exerted by the car at this speed?

A mass M_1 is accelerated from rest at X along a horizontal frictionless surface by a tight string passing over a frictionless pulley and attached to mass M_2.



M_2 falls from its rest position a distance, d, where it strikes the floor. g is the acceleration due to gravity.

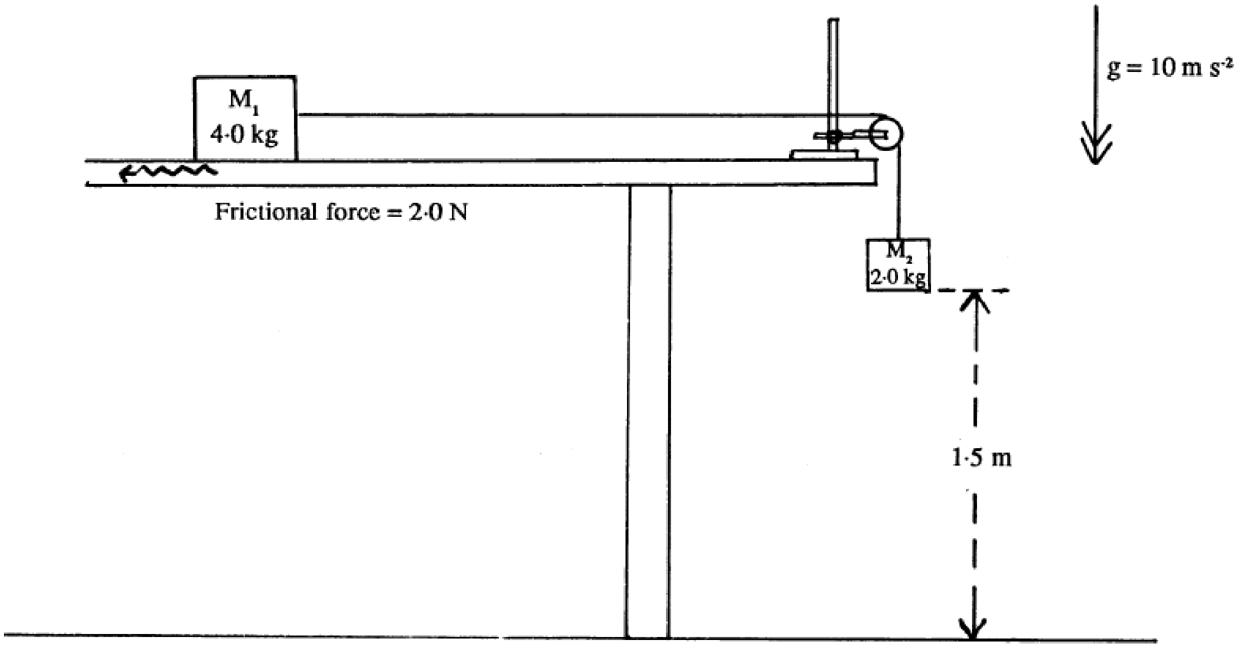
Example 56 (1986 Question 21, 1 mark)

What is the acceleration of M_1 in the section XY?

Example 57 (1986 Question 22, 1 mark)

What is the speed of M_1 at Y?

In a laboratory experiment two blocks, M_1 (of mass 4.0 kg).and M_2 (of mass 2.0 kg) are connected by a light inextensible string as shown below. There is a constant frictional force of 2.0 N between M_1 and the table. All other friction forces should be ignored.
The masses are released from rest at the positions shown in the diagram.



Example 58 (**1988 Question 12, 1 mark)**

What is the magnitude of the acceleration of the masses?

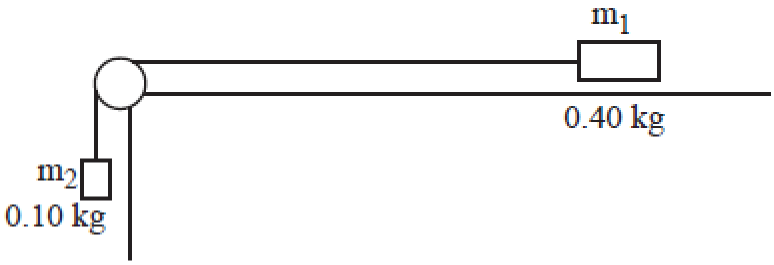
Example 59 (**1988 Question 13, 1 mark)**

What is the magnitude of the tension in the string?

Example 60 (**1988 Question 14, 1 mark)**

What is the speed of M_1 at the moment when M_2 hits the floor?

Two physics students are conducting an experiment in which a block, m_1, of mass 0.40 kg is being pulled by a string across a frictionless surface. The string is attached over a frictionless pulley to another mass, m_2, of 0.10 kg. The second mass, m_2, is free to fall vertically. This is shown below.



The block is released from rest.

Example 61 (**2010 Question 3, 1 mark)**

What is the acceleration of the block m1?

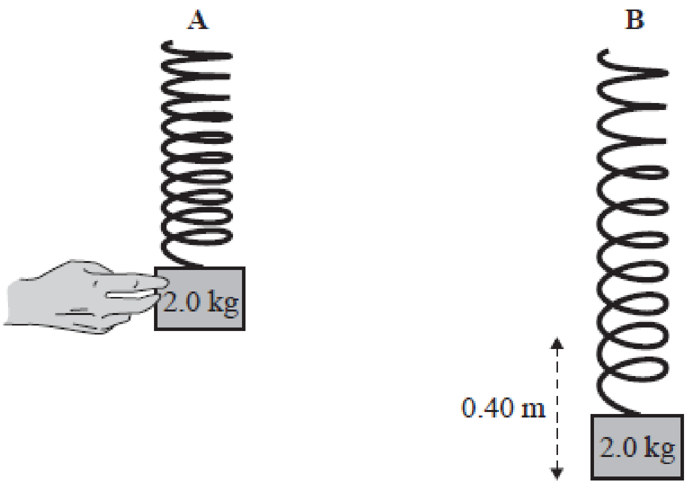


Figure A shows an ideal spring with a 2.0 kg mass attached. The spring-mass system is held so that the spring is not extended. The mass is **gently** lowered and the spring stretches until, in Figure B, the spring-mass system is at rest. The spring has extended by 0.40 m.

Example 62 (**2010 Question 13, 1 mark)**

What is the value of the spring constant, *k*, of the spring?