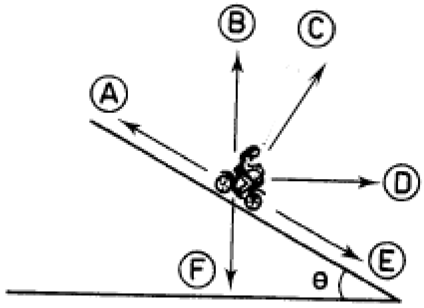
Multiple Choice



Example 1 (1976 Question 9, 1 mark) 63%

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?
Assuming no friction as brakes are off the force of the road on the bicycle is perpendicular to the surface of the road.

∴ C (ANS)

The cyclist now brakes so that his speed is constant.

Example 2 (1976 Question 10, 1 mark) 54%

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

Since the speed and in this case velocity is constant the acceleration must be zero.

∴ D (ANS)

Example 3 (1976 Question 11, 1 mark) 32%

Which arrow (A – F) now **best** represents the direction of the force of the road on the bicycle?
The sum of the forces must be zero, therefore the force of the road on the bicycle must be the sum of the normal reaction (C) and the frictional force on the tyres (A).

∴ B (ANS)

Example 4 (1981 Question 5, 1 mark) 67%

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

The man and the parachute are travelling at a constant velocity, so the net force acting on the man is zero ∴ D (ANS)

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 5 (1984 Question 24, 1 mark) 34%

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.

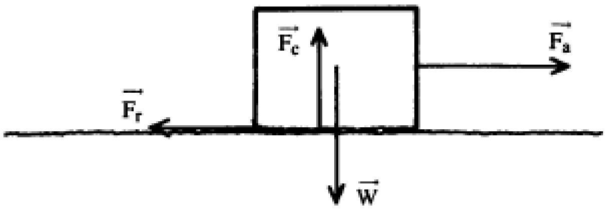
C the ball is accelerating upwards, so F_C must be greater than *W*.

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

The ball is momentarily stationary, but it is about to rebound. This means that to get it to rebound the net force acting on it must be upwards.

∴ C (ANS)

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 6 (1985 Question 17, 1 mark) 3%

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.

Newton's third law states that $F_{on\ A\ by\ B} = -F_{on\ B\ by\ A}$

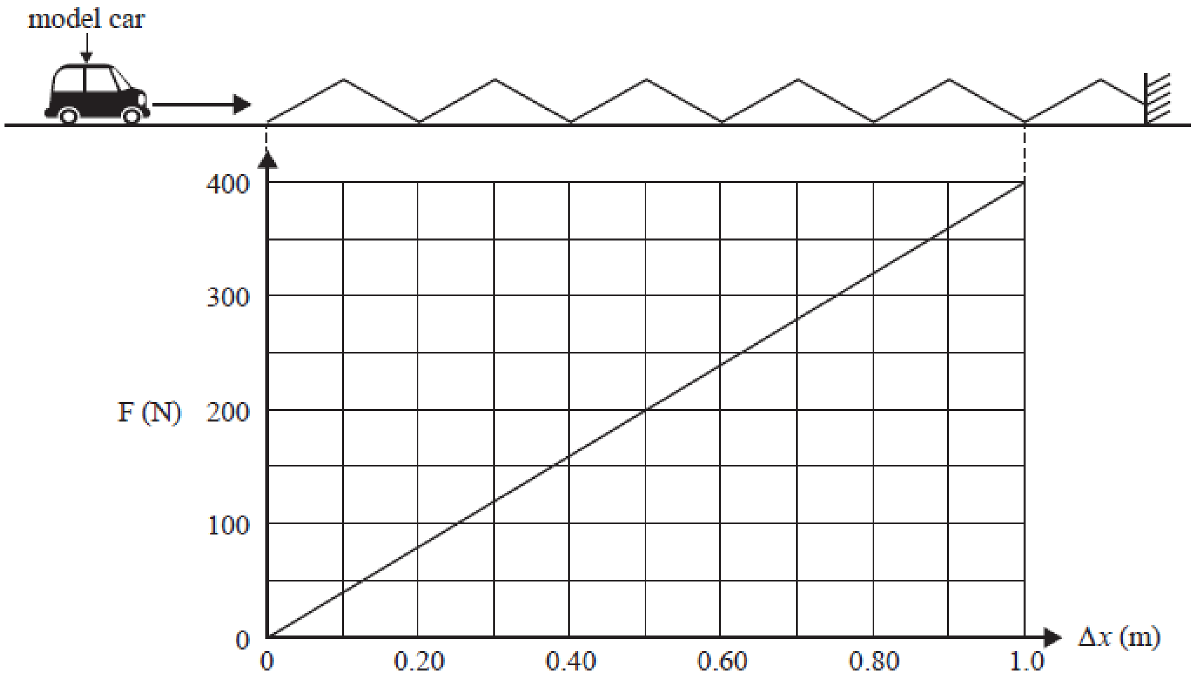
The weight of an object can be written as

$F_{on\ mass\ by\ Earth}$.

From an action reaction pair perspective, this means that the opposite to the weight is:

$F_{on\ Earth\ by\ mass}$. *∴ A (ANS)*

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 7 **(2017 Question 12, 1 mark) 89%**

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

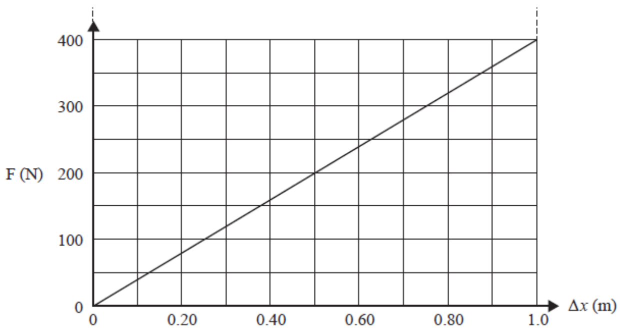
A. 100 N m^{-1}

B. 200 N m^{-1}

C. 400 N m^{-1}

D. 800 N m^{-1}

Use $F = k\,\Delta x$, k is the gradient of the F vs Δx graph.



Use points as far apart as possible and which you can read as accurate as possible,

$$\therefore k = \frac{400}{1}$$

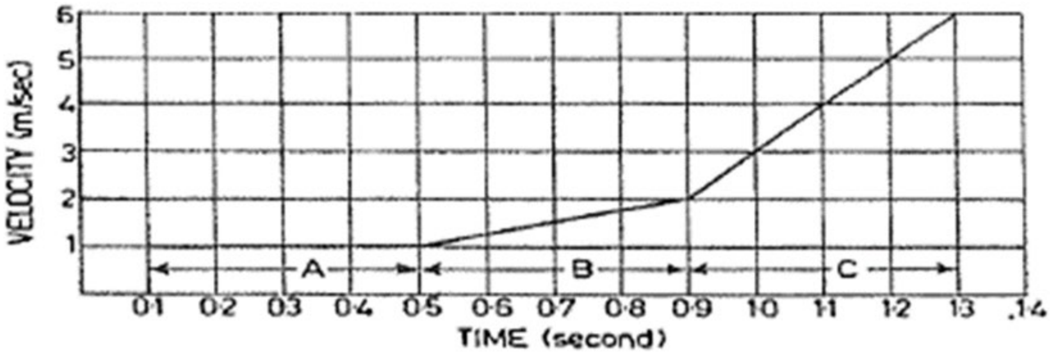
*∴ **C** (ANS)*

Extended questions

A sled carrying *seven* bricks was pulled along a horizontal floor, in a straight line, by a rope which exerts a constant force on the sled.

The velocity-time graph is shown in the diagram. In the part of the motion represented by section A of the graph the sled was pulled across a carpeted floor; in sections B and C the floor surface was smooth (i.e. friction was negligible here). At the end of section B, several bricks fell from the sled.

Mass of 1 brick = mass of sled = 2·0 kg.



Example 8 1969 Question 29, 1 mark 56%

What was the magnitude of the frictional force of the carpet on the sled over section A?

When the seven bricks were on the sled and the friction was zero, i.e. section B, the acceleration was $\frac{2-1}{0.9-0.5}$ *= 2.5 m s*$^{-2}$

The total mass of the led and bricks was

8 × 2 = 16 kg $\therefore$ *force = 16 × 2.5* $\therefore$ *F = 40 N*

When the sled was on the carpet the acceleration was zero, therefore the frictional force was the same as the driving force

$\therefore$ ***40 N (ANS)***

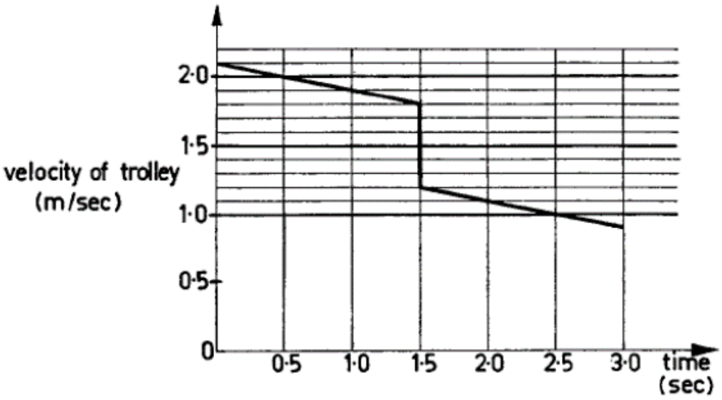
Example 9 1969 Question 32, 1 mark 53%

How many bricks fell off the sled at the end of section B?

Acceleration now is (gradient of the graph) $\frac{6-2}{1.3-0.9} = 10\ ms^{-2}$ *so mass is* $m = \frac{F}{m} = \frac{40}{10} = 4\ kg$ *so only 1 brick left and so 6 fell off.*

$\therefore$ ***6 (ANS)***

A trolley of mass 6.0 kilogram is given a push and then allowed to roll freely along a table. Its velocity is measured continuously. At time 1.5 second a lump of clay is dropped vertically onto the trolley.



Example 10 1970 Question 12, 1 mark 72%

Calculate the frictional force acting on the trolley over the first 1.5 second.

Use F = ma, to find the frictional force opposing the motion.

From the graph the acceleration is $\frac{\Delta v}{\Delta t}$

$\therefore a = \frac{1.8 - 2.1}{1.5 - 0}$

$\therefore a = \frac{-0.3}{1.5} = -0.2$

$\therefore F = 6.0 \times -0.2$

$= -1.2$ N

$\therefore$ ***F = 1.2 N (ANS)***

Example 11 1970 Question 15, 1 mark 29%

Note that the slopes of the graph before and after 1.5 second are equal. From this it may be deduced

A. that the frictional force is constant.

B. that the frictional force decreases linearly with time.

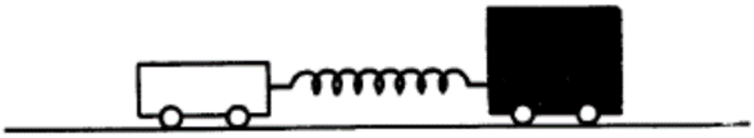
C. that the frictional force is directly proportional to the weight.

D. that the fictional force decreases linearly with the velocity.

The slope is the acceleration.

Since $a = \frac{F}{m}$*, this implies that the frictional force is directly proportional to the mass, hence it will be directly proportional to the weight.*

$\therefore$ ***C (ANS)***



A light spring is permanently connected between two trolleys of masses, 1.0 kg and 4.0 kg which can move along a straight horizontal track. The spring is compressed and then the trolleys are released simultaneously from rest.

Example 12 1971 Question 41, 1 mark 76%

What is the acceleration of the lighter trolley when the acceleration of the heavier trolley is 8 m s^{-2}?

The spring will exert the same force in both directions.

$\therefore m_1 \times a_1 = m_2 \times a_2$

$\therefore 1 \times a = 4 \times 8$

$\therefore a = 32\ m\ s^{-2}$

$\therefore$ ***32 m s^{-2} (ANS)***

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 13 (1977 Question 1, 1 mark) 72%

Calculate the acceleration of the car.

Use $v^2 = u^2 + 2ax$

$\therefore 20^2 = 10^2 + 2x\ a \times 200$

$\therefore 400 = 100 + 400a$

$\therefore 300 = 400a$

$\therefore$ ***a = 0.75 ms^{-2} (ANS)***

Example 14 (1977 Question 2, 1 mark) 62%

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

The net force is found from $F_{net} = ma$

$\therefore F = 800 \times 0.75$

$\therefore$ ***F = 600 N (ANS)***

Example 85 (1977 Question 3, 1 mark) 72%

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

The towing car also needs to overcome the frictional forces.

$\therefore F_{towing\ car} = 600 + 500$

$\therefore$ ***$F_{towing\ car}$ = 1100 N (ANS)***

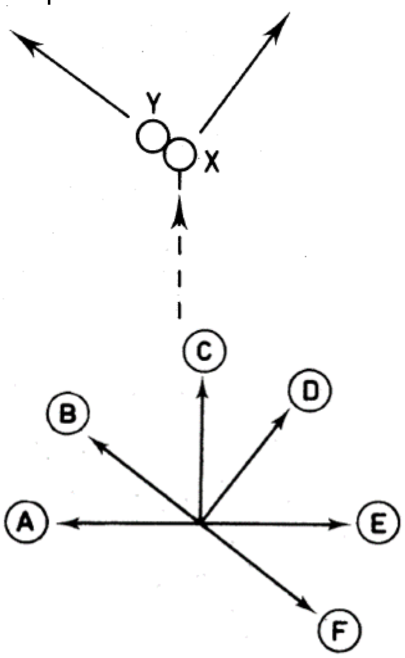
Example 96 (1977 Question 4, 1 mark) 74%

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?

Since the speed is constant, the net force must equal zero. The magnitude of the net force is the same as the magnitude of the frictional force

∴F = 500 N (ANS)

During a game of billiards, ball X strikes the stationary ball Y so that X and Y follow the paths shown.



Example 110 1978 Question 23, 1 mark 59%

At the instant of impact, which of the arrows above could represent the direction of

(i) the force exerted on ball Y by ball X?

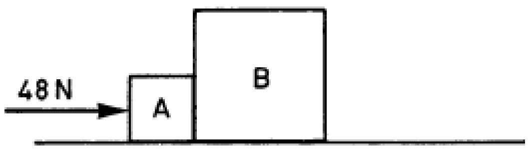
Ball Y will accelerate (move) in the direction B. Therefore the force of X on Y is

∴ B (ANS)

(ii) the force exerted on ball X by ball Y?

By definition the force of Y on X is

∴ F (ANS)



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 118 (1979 Question 8, 1 mark) 96%

What is the mass of **B**?

Using $F = \Sigma m \times a$
We get $48 = (4 + B) \times 4$
$\therefore 12 = 4 + B$
$\therefore B = 8$ kg (ANS)

Example 19 (1979 Question 9, 1 mark) 43%

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

The force that A exerts on B is the force that accelerates B.
Using $F_{net} = ma$
$F = 8 \times 4$
$\therefore F_{on\ B\ by\ A} = 32$ N (ANS)

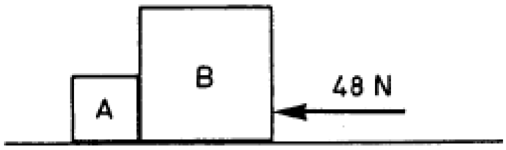
Example 20 (1979 Question 10, 1 mark) 71%

What is the magnitude of the force exerted by **B** on **A**?
This is the classic example of Newton's third law.

$F_{on\ A\ by\ B} = - F_{on\ B\ by\ A}$

We are asked for the magnitude,
$\therefore F_{on\ A\ by\ B} = 32$ N (ANS)

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



Example 21 (1979 Question 11, 1 mark) 42%

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

Since the force is the same as before and the total mass hasn't changed, the acceleration will also be 4.0 m s^{-2}.
Therefore to accelerate 4.0 kg at 4.0 m s^{-2} requires a force of 16 N
$\therefore F_{B\ on\ A} = 16$ N (ANS)

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 22 (1980 Question 14, 1 mark) 68%

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

The net force to accelerate a 1.0 kg mass at 2.0 m s^{-2} is 2 N.
To overcome the weight, the spring balance needs to supply a 10 N force.
Therefore the total force required to accelerate the mass upwards at 2.0 m s^{-2} will be $10 + 2 = 12$ N
$\therefore$ 12 N (ANS)

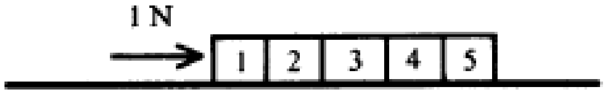
Example 23 (1980 Question 15, 1 mark) 88%

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

If everything is moving up at a constant velocity, then the spring balance only needs to overcome the weight (otherwise the mass would fall to the floor of the lift).

∴ 10 N ***(ANS)***

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 2412 (1985 Question 14, 1 mark) 36%

What force does block 4 exert on block 5?

The force the block 4 exerts on block 5, causes block 5 to accelerate. The system is accelerating at 0.2 m s^{-2}.

Therefore the net force on block 5 is

$F_{net} = ma$

$F = 1 \times 0.2$

∴ 0.2 N ***(ANS)***

Example 25 (1985 Question 15, 1 mark) 30%

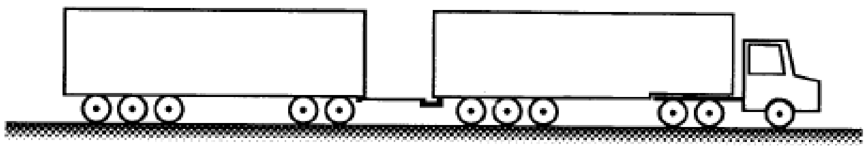
What force does block 3 exert on block 4?

The force the block 3 exerts on block 4, causes blocks 4 and 5 to accelerate. The system is accelerating at 0.2 m s^{-2}. Therefore, the net force on block 4 is

$F_{net} = ma$

$F = (1 + 1) \times 0.2$

∴ 0.4 N ***(ANS)***



Example 26 (1991 Question 4, 1 mark)

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

Driving force – friction forces = net force $F_{net} = ma$

$3.9 \times 10^4 - (2 \times 2.5 \times 10^3) = 4.0 \times 10^4 \times a$

$\therefore a = \dfrac{3.9 \times 10^4 - 0.5 \times 10^4}{4.0 \times 10^4}$ $\therefore \boldsymbol{a = 0.85\ ms^{-2}}$ ***(ANS)***

Example 27 (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?

The road train is moving at constant speed, therefore, the net force acting on the trailer must be zero. The tension needs to overcome the frictional force.

$\therefore T = 2.5 \times 10^3$ N (ANS)

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 138 (1991 Question 6, 1 mark)

How far will it travel before coming to rest?

It is simplest to treat the truck and trailer as the one system. The net retarding force is 5×10^3 N.

The deceleration is $\frac{F}{m} = \frac{5 \times 10^3}{4.0 \times 10^4}$

$= 0.125\ ms^{-2}$

Now use $v^2 - u^2 = 2ax$

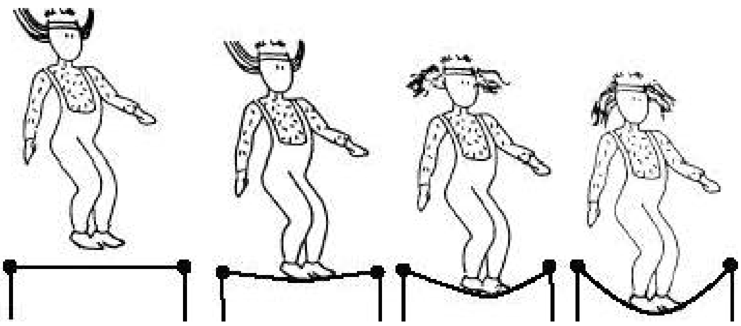
$\therefore -20^2 = 2 \times 0.125 \times$ 'x'

$\therefore x = 400 \div 0.25$

$\therefore x = 1600$ m

$\therefore x = 1.6 \times 10^3$ m (ANS)

Anna is jumping on a trampoline. The figure below 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 149 **(1999 Question 6, 2 marks) 55%**

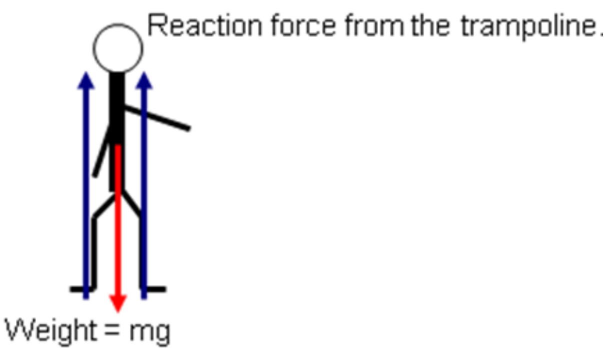
What is the direction of Anna's acceleration at the time shown in **Figure 4c**? **Explain** your answer.

Up

At this time Anna is travelling downwards and slowing down. This means that her acceleration is up, because it is opposing the motion (she is slowing down).

Example 30 (1999 Question 7, 3 marks) 50%

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.



The reaction force > weight, because she is slowing down, ie. a net upward force.

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 31 (2000 Question 11, 2 marks) 58%

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

Just $F_{net} = ma$

Using the mass of the system.

$\therefore F_{net} = (1300 + 900) \times 1.25$

$= 2.75 \times 10^3$ N (ANS)

Example 32 (2000 Question 12, 3 marks) 58%

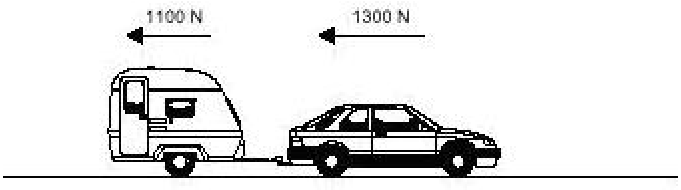
What is the tension in the coupling between the car and the caravan as they start to accelerate?

For this question think of the caravan as an object that is accelerating that is pulling it. So $F_{net} = ma$

$= 900 \times 1.25$

$= 1.13 \times 10^3$ N (ANS)

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 33 (2000 Question 13, 2 marks) 63%

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

If the car is travelling at a constant velocity then there is no net force acting on the car. Therefore the magnitude of the driving force from the motor equals the retarding force of the car and the caravan.

$F_d = 1300 + 1100$

$= \mathbf{2400\ N}$ ***(ANS)***

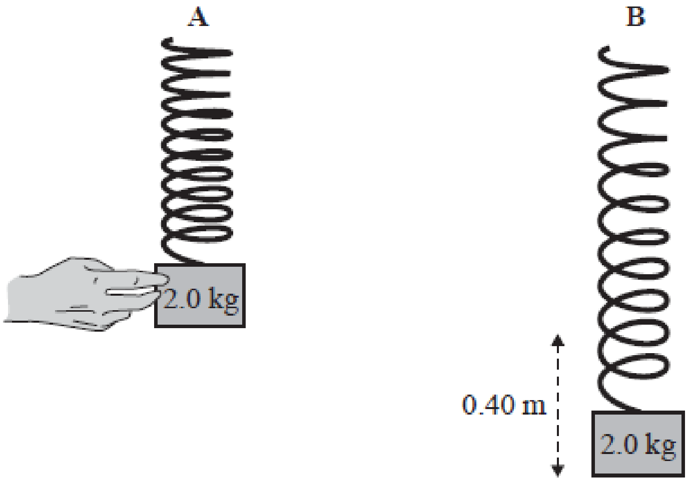


Figure A shows an ideal spring with a 2.0 kg mass attached. The spring-mass system is held so that the spring is not extended. The mass is **gently** lowered and the spring stretches until, in Figure B, the spring-mass system is at rest. The spring has extended by 0.40 m.

Example 34 (2010 Question 13, 1 mark) 55%

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

When the spring has extended 0.40 m, the mass is in equilibrium.

$\therefore mg = k\Delta x$.

You must ALWAYS use Δx, to remind yourself that it is the extension of the spring, not the length of the spring that is used in calculations.

$\therefore 2.0 \times 10 = k \times 0.40$

$\therefore \mathbf{k = 50\ N\ m^{-1}}$ ***(ANS)***