Solutions

Example 1 1976 Question 9, 63%

The force of the road on the bicycle is always perpendicular to the surface of the road.

∴ **C (ANS)**

The road cannot push sideways.

Example 2 1976 Question 10, 54%

Since the speed is constant the acceleration must be zero.

∴ **D (ANS)**

Example 3 1976 Question 11, 32%

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, 67%

The man and the parachute are travelling at a constant speed, so the net force acting on the man is zero

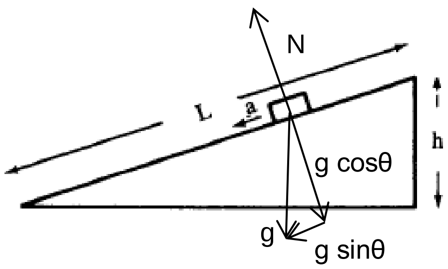
∴ **D (ANS)**

Example 5 1981 Question 6, 30%

The direction of the girl's acceleration is north. Therefore the net force acting on her must be northerly.

∴ **A (ANS)**

Example 6 1981 Question 7, 76%



In this case the unbalanced acceleration on the block is given by g sinθ.

$\therefore a = g\frac{h}{L}$

$\therefore k = g$

∴ **C (ANS)**

Example 7 1983 Question 4, 40%

With a constant thrust the rocket will accelerate in the direction of the thrust. This means that the answer needs to be D, E or F. Once the thrust stops, there will not be any forces acting on the rocket, so it will continue to travel in the same direction.

∴ **E (ANS)**

Example 8 1984 Question 23, 32%

With air resistance, there are now two forces acting on the golf ball its weight, and air resistance in the opposite direction to the motion. (to the left).

∴ **D (ANS)**

Example 9 1984 Question 24, 34%

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)**

Example 10 1985 Question 17, 3%

Newton's third law states that

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

The weight of an object can be written as

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

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

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

∴ **A (ANS)**

Example 11 2000 Question 10, 57%

This question was testing you understanding of how speed and stopping distance is related. Let's assume the mass of the car, and the force stopping it, are constant.

That is, if the car has a kinetic energy of $\frac{1}{2}mv^2$ and it requires a force by a distance to stop it then:

$$\tfrac{1}{2}mv^2 = F \times d$$

if the speed of the car is doubled then the stopping distance in 4 times larger. This is known as a square relationship.

For this question the speed of the car is

30 km h^{-1} and the stopping distance is 10 m.

The speed of the car is then doubled to

60 km h^{-1} then because the speed has doubled the stopping distance is now 4 times the 10 m, which is 40 m

∴ **C (ANS)**

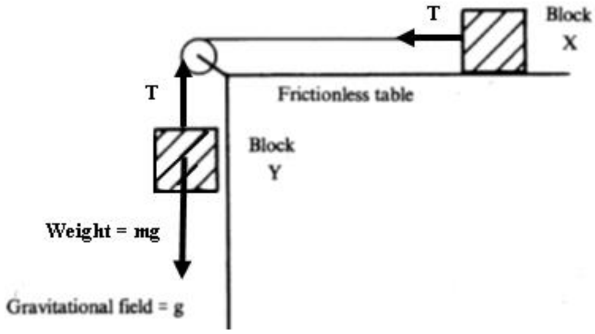
Example 12 1981 Question 9, 79%

Block X is initially stationary and remains stationary until the hand supporting Block Y is removed. Therefore the net force on Block X is zero.

∴ **A (ANS)**

Example 13 1981 Question 10, 34%

When Block Y is released, its weight accelerates it downward.



As the two blocks are connected by a string, they are going to both have the same acceleration when released.

The net force acting on Block Y is given by mg – T = ma
The net force acting on Block X is given by T = ma

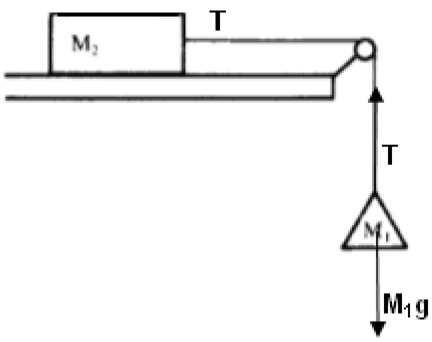
Substituting for T gives mg – ma = ma

$$\therefore mg = 2ma$$

$$\therefore ma = \frac{mg}{2}$$

$\therefore$ **B (ANS)**

Example 14 1983 Question 7, 62%



As the two blocks are connected by a string, they are going to both have the same acceleration when released.

The net force acting on Block M_1 is given by $M_1g - T = M_1a$
The net force acting on Block M_2 is given by $T = M_2a$

Substituting for T gives $M_1g - M_2a = M_1a$

$$\therefore M_1g = M_1a + M_2a$$

$$\therefore M_1g = (M_1 + M_2)a$$

$$\therefore a = \frac{M_1 g}{M_1 + M_2}$$

$\therefore$ **B (ANS)**

Example 15 2017 Question 7

Use f = ma

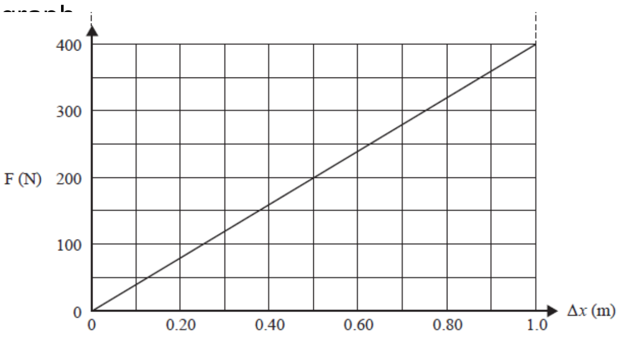
$\therefore 4 = 2 \times a$

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

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

Example 16 2017 Question 12

Use F = k Δx
$\therefore$ k is the gradient of the F vs Δx graph



Use points as far apart as possible,

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

$\therefore$ k = 400 N m^{-1}

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

Example 17 1973 Question 8, 58%

Using a = $\frac{F}{m}$, the maximum acceleration is caused by the maximum force that the car can exert on the road, (hence the maximum force that the road will exert on the car to accelerate the car).
If F_{max} is fixed, then tripling the mass will result in $\frac{1}{3}$ the original acceleration.

$\therefore$ **1 m s^{-2} (ANS)**

Example 18 1976 Question 1, 75%

The distance travelled is the area under the graph. Use the trapezium formula,
A = ½(a +b)h to get
d = ½ x (3000 + 3500) × 30
$\therefore$d = 97500 m
$\therefore$**d = 9.8 x 10^4 m (ANS)**
(this is a bit difficult to express when you take sig figs into consideration)

Example 19 1976 Question 2, 58%

Use F_{net} = ma to find the net force acting
The gradient of the graph over the first 300 seconds will give the acceleration.

$\therefore$ a = $\frac{30}{300}$ = 0.1

$\therefore$ F = 5.0 × 10^5 × 0.1
$\therefore$ **F = 5.0 × 10^4 N (ANS)**

Example 20 1976 Question 3, 69%

The engine is required to provide a net force of 5.0 x 10^4, so the engine must also provide the force required to overcome the frictional force of 1.5 × 10^4 N.
$\therefore$ F_{engine} = 5.0 × 10^4 + 1.0 × 10^4
$\therefore$ **F_{engine} = 6.5 × 10^4 N (ANS)**

Example 21 1976 Question 4, 24%

Power is the rate of doing work, it is given by the formula P = Fv.
When the train is travelling at a constant speed the engine just needs to overcome the frictional forces.

$\therefore$ $P = 1.5 \times 10^4 \times 30$
$\therefore$ $P = 4.5 \times 10^5$
$\therefore$ **P = 450 kW (ANS)**

Example 22 1977 Question 1, 72%

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 23 1977 Question 2, 62%

The net force is found from $F_{net} = ma$
$\therefore$ $F = 800 \times 0.75$
$\therefore$ **F = 600 N (ANS)**

Example 24 1977 Question 3, 72%

The towing car also needs to overcome the frictional forces.
$\therefore$ $F_{towing\ car} = 600 + 500$
$\therefore$ **$F_{towing\ car}$ = 1100 N (ANS)**

Example 25 1977 Question 4, 74%

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)

Example 26 1979 Question 8, 96%

Using F = Σm x a
We get 48 = (4 + B) × 4
∴ 12 = 4 + B
∴ B = 8 kg (ANS)

Example 27 1979 Question 9, 43%

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

Example 28 1979 Question 10, 71%

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,
∴ $F_{on\ A\ by\ B}$ = 32 N (ANS)

Example 29 1979 Question 11, 42%

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
∴ $F_{B\ on\ A}$ = 16 N (ANS)

Example 30 1980 Question 14, 68%

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
∴ 12 N (ANS)

Example 31 1980 Question 15, 88%

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)

Example 32 1985 Question 14, 36%

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 × 0.2
∴ 0.2 N (ANS)

Example 33 1985 Question 15, 30%

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

$F_{net} = ma$

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

$\therefore$ **0.4 N** **(ANS)**

Example 34 1986 Question 1

Using $F_{net} = ma$, we need to find 'a'.
The acceleration is the gradient of the velocity-time graph.
The question asks for the **magnitude**. The gradient is: $\frac{\Delta v}{\Delta t} = \frac{-5}{1}$

$\therefore a = -5$

Therefore $F = 4 \times 5$

$\therefore$ **F = 20 N** **(ANS)**

Example 35 1986 Question 2

This is equal to (in magnitude), but in the opposite direction to the force of the floor on the block.

$\therefore$ **F = 20 N** **(ANS)**

Example 36 1987 Question 5, 72%

The acceleration is the gradient of the velocity time graph.
gradient is: $\frac{\Delta v}{\Delta t} = \frac{14.4}{2}$

$\therefore$ **a = 7.2 m s^{-2}** **(ANS)**

Example 37 1987 Question 6, 76%

This ratio must always be 1.

Examiners comment
This question simply asked candidates to realise that the force of gravity would be the same irrespective of speed.

Example 38 1987 Question 7, 76%

Using $F_{net} = ma$
F = 100 × 7.2
∴ F = 720 N (ANS)

Example 39 1987 Question 8, 77%

At 20 secs, the velocity is constant, this means that the net force must be zero. Therefore the acceleration is zero.
∴ a = 0 (ANS)

Examiners comment
Questions 7 and 8 tested the relationship between resultant force and acceleration. These two questions, in conjunction with others, seem to reflect many candidates' lack of appreciation of Newton's laws. "If the velocity is constant there is no acceleration and hence no resultant force.

Example 40 1991 Question 4

Driving force – friction forces = net force
$F_{net} = ma$
$3.9 \times 10^4 - (2 \times 2.5 \times 10^3) = 4.0 \times 10^4 \times a$
$\therefore a = \dfrac{3.9 \times 10^4 - 0.5 \times 10^4}{4.0 \times 10^4}$
∴ a = 0.85 ms^{-2} (ANS)

Example 41 1991 Question 5

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.
∴ T = 2.5 × 10^3 N (ANS)

Example 42 1991 Question 6

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 $\dfrac{F}{m} = \dfrac{5 \times 10^3}{4.0 \times 10^4}$
$= 0.125$ 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
∴ x = 1.6 x 10^3 m (ANS)

Example 43 1996 Question 5, 80%

The acceleration is $\frac{\Delta v}{\Delta t} = \frac{20-18}{4}$

$= 0.5\ ms^{-2}$

$\therefore$ F = 1100 × 0.5

$\therefore$ **F = 5.5 × 10^2 N (ANS)**

Examiners comments

Students needed to calculate the acceleration (change in velocity divided by time) and then apply Newton's 2nd Law (F = ma) to determine the net force, resulting in an answer of 550 N.

Example 44 1996 Question 6, 40%

Power is the rate at which work is being done, $P = \frac{Fd}{t}$

Power is found from P = Fv

$\therefore$ P = 5.5 × 10^2 × 20

$\therefore$ **P = 1.1 × 10^4 W (ANS)**

Examiners comments

In order to maintain a constant speed the driving force needed to be equal and opposite to the resistance force, as calculated in the previous question. The power at the wheels is then calculated using the formula, P = Fv. where F is the driving force at the wheels of the car. Assuming the correct answer to
the previous question, this calculation resulted in a power of 11 000 W. Consequentially correct answers, arising from an incorrect answer to question 5, were also scored as correct.
The most common incorrect answer
(220 000 W) arose from students applying the formula, P = Fv, but substituting in the weight force for F.

Example 45 2004 Question 1, 70%

Since the speed is constant, the net force is zero. Hence the driving force exerted by the car must equal the sum of the resistive forces.

$\therefore$ 1400 + 1200 = **2600 N (ANS)**

Example 46 2004 Question 2, 73%

The tension in the coupling (towbar) is the only force acting forwards on the trailer. $\therefore$The net force on the trailer must give rise to its acceleration.

Using F_{net} = ma

gives F = 1200 × 1.20

= 1440 N.

This gives the net force acting on the trailer to be 1440 (to provide the acceleration) and 1200 (to overcome friction)

$\therefore$ Tension = 1200 + 1440

= **2640 N (ANS)**

Example 47 2004 Question 3, 37%

You need to convert both the 72 km h^{-1} and 108 km h^{-1} to m s^{-1}.

This is done by dividing by 3.6. (This should be on your cheat sheet)

$\therefore$ 72 km h^{-1} = 20 m s^{-1}

and 108 km h^{-1} = 30 m s^{-1}.

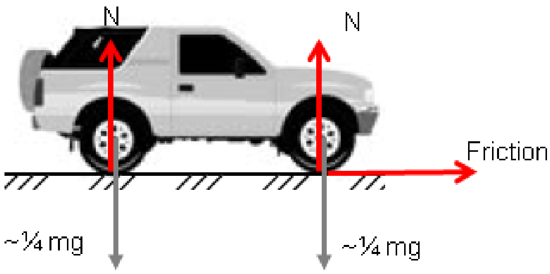
Use $v^2 = u^2 + 2ax$

$\therefore\ 30^2 = 20^2 + 2 \times 1.20 \times x$

$\therefore\ 900 - 400 = 2.4 \times x$

$\therefore\ \frac{500}{2.4}$ = **208 m. (ANS)**

Example 48 2004 Question 8, 37%

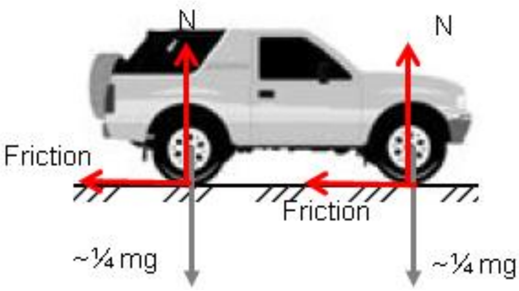


The net force acting on the car MUST be in the direction of the acceleration. This net force can only come from the frictional contact between the tyres and the road. You need to remember that the frictional forces oppose the motion, but in this case, to get the car to move forwards the tyre actually wants to move backwards at ground level.

Examiners comment

The average score for Question 8 (1.1/3) indicates that the concept of friction as a driving force was poorly understood. While many students were aware that there had to be a net force acting forwards to accelerate the car, the origin and point of application of this force was rarely correctly sketched. In fact, many students still sketched the road–tyre friction force acting backwards so as to oppose the motion of the car. It was also disappointing to note the number of sketches that did not show the correct point of application of the weight, normal or frictional forces. It is quite apparent that VCE Physics students need more practice in drawing free-body force diagrams.

Example 49 2004 Question 9, 45%



The net force acting on the car MUST be in the direction of the acceleration. This net force can only come from the frictional contact between the tyres and the road. Since the car is decelerating the net force must be in the opposite direction to the motion.

Examiners comment

The average score for this question (0.9/2) again indicates that students found this nearly as difficult as the previous question and that friction as a braking force was not thoroughly understood.

Example 50 1999 Question 6, 55%

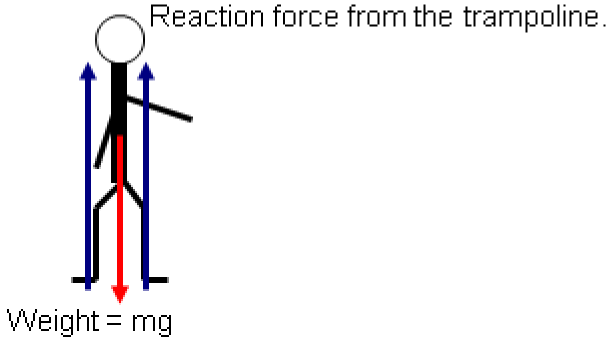
Up

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).

Examiners comment

Anna was travelling downwards and slowing, hence the direction of her acceleration was upwards. The main errors were to reason that the net force was her weight and thus her acceleration was downwards, or that since she was moving downwards then her acceleration must also be downwards. It was certainly clear that many students experience great difficulty in distinguishing between velocity and acceleration vectors, (a number of students based their answer on the state of Anna's hair at the instant).

Example 51 1999 Question 7, 50%



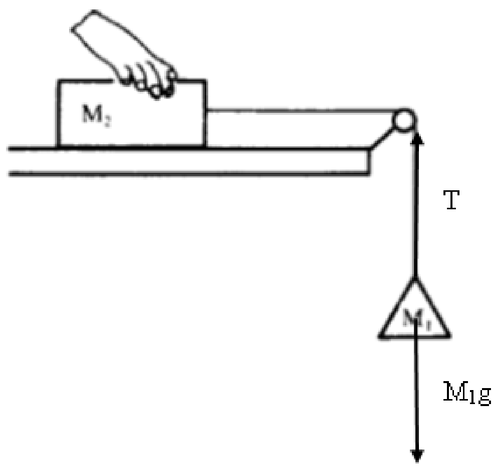
The reaction force > weight, because she is slowing down, ie. a net upward force.

Examiner's comment

Students were expected to draw two force arrows on Figure C. One arrow was the weight force, acting through Anna's centre of mass and the other arrow being the normal contact force, acting at her feet. The arrow for the normal contact force should have been longer than the weight force arrow.

The average mark for this question was 1.5/3, with the most common errors being in either choosing the incorrect point of application for each force or in not indicating the relative magnitudes as specifically asked in the question.

Example 52 1983 Question 6, 84%



Since the block is being held, M_1 is stationary, and going to remain stationary, therefore the net force acting on it is zero.

$\therefore$ T = M_1g

Example 53 2000 Question 11, 58%

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 54 2000 Question 12, 58%

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)

Examiners comment
Application of Newton's Second Law for the caravan alone resulted in an answer of 1.125 ·× 10^3 N for the tension in the coupling. Students needed to be aware that the driving force for the caravan was provided solely by the tension in the coupling.

Example 55 2000 Question 13, 63%

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.
$F_d = 1300 + 1100$
$= 2400$ N (ANS)

Examiners comment
Constant velocity implies a net force of zero. Hence, the driving force must be equal and opposite to the retarding forces, i.e. 2400 N.
Any errors were due to students not realising that constant speed in a straight line implies a net force of zero.

Example 56 1986 Question 21

As the two blocks are connected by a string, they are going to both have the same acceleration when released.
The net force acting on Block M_2 is given by $4g - T = 4a$
The net force acting on Block M_1 is given by $T = 1a$
Substituting for T gives $4g - a = 4a$

$$\therefore 4g = 4a + a$$
$$\therefore 4g = 5a$$
$$\therefore a = \frac{4 \times 10}{5}$$

$\therefore 8$ m s^{-2} (ANS)

Example 57 1986 Question 22

Use $v^2 - u^2 = 2ax$
$\therefore v^2 - 0 = 2 \times 8 \times 1$
$\therefore v^2 = 16$
$\therefore v = 4$ m s^{-1} (ANS)

Example 58 1988 Question12

As the two blocks are connected by a string, they are going to both have the same acceleration when released.

The net force acting on Block M_2 is given by $2g - T = 2a$
The net force acting on Block M_1 is given by $T - 2 = 4a$
$\therefore T = 4a + 2$
Substituting for T gives $2g - (4a + 2) = 2a$
$\therefore 2g = 2a + 4a + 2$
$\therefore 20 = 6a = 2$
$\therefore 18 = 6a$
$\therefore$ **a = 3 m s^{-2} (ANS)**

Example 59 1988 Question 13

Using T = 4a + 2, give T = 4 x 3 + 2
$\therefore$ **= 14 N (ANS)**

Example 60 1988 Question 14

Use $v^2 - u^2 = 2ax$
$\therefore v^2 - 0 = 2 \times 3 \times 1.5$
$\therefore v^2 = 9$
$\therefore$ **v = 3 m s^{-1} (ANS)**

Example 61 2010 Question 3, 35%

The weight of m_2 will cause both blocks to accelerate at the same rate.

Using $\Sigma F = (m_1 + m_2)a$
gives $0.1 \times 9.8 = (0.4 + 0.1)a$
$\therefore 0.98 = 0.5 \times a$
$\therefore a = 1.96$
$\therefore$ **a = 2 m s^{-2} (ANS)**

Example 62 2010 Question 13, 55%

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.
$\therefore 2.0 \times 10 = k \times 0.40$
$\therefore$ **k = 50 N m^{-1} (ANS)**