**DIAGNOSTIC /REMEDIAL TEST**

**NEWTON’S LAWS**

This test is one of a series in Introductory Physics made available on the Website of the School of Physics, Monash University, Australia ([www.physics.monash.edu.au/community](http://www.physics.monash.edu.au/community)).

This test is NOT for the purposes of assessment. It is to assist you in locating misconceptions and misunderstandings and generally to assist you in your study of Physics. You should work by yourself and at your own pace following the directions given. It is not necessary to attempt the test all at once. You may like to do it bit-by-bit, waiting until you have covered a particular topic in class or in your reading of your text book or you may like to "plunge in " before you begin your study of the topic.

Questions are on the left hand (even-numbered) pages. While reading or working on these, **keep the right hand (odd-numbered) answer page covered. DO NOT PEEK AT THE ANSWERS ON THE RIGHT HAND PAGE !**

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COVER THE RIGHT HAND (ODD-NUMBERED) PAGES

DO NOT PEEK!

In the following questions neglect the fact that the earth is rotating on its axis and that it is revolving around the sun. Answer the questions from your "point of view" when you are sitting on the ground. In more sophisticated terms you are asked to give your answers relative to the earth's frame of reference.

1

For each of the following objects you are asked to state whether the object is at rest or whether it is in a state of uniform motion or not, and to list the forces acting on it and also to state whether these forces balance.

(a) Your house.

At rest or in uniform motion or not ?...........

Forces acting on the it are...............

Do these forces balance?...........

(b) A stone sliding over ice which is assumed frictionless.

At rest or in uniform motion or not ?...........

Forces acting on the it are...............

Do these forces balance?...........

(c) A leaf falling vertically downwards with constant speed.

At rest or in uniform motion or not ?...........

Forces acting on the it are...............

Do these forces balance?...........

(d) A caravan being pulled along a straight road at constant speed.

At rest or in uniform motion or not ?...........

Forces acting on the it are...............

Do these forces balance?...........

(e) A satellite travelling with constant speed in a circular orbit around the Earth.

At rest or in uniform motion or not ?...........

Forces acting on the it are...............

Do these forces balance?...........

(f) A fly standing on the rotating turntable of your record player.

At rest or in uniform motion or not ?...........

Forces acting on the it are...............

Do these forces balance?...........

(g) A football when in flight after being kicked.

At rest or in uniform motion or not ?...........

Forces acting on the it are...............

Do these forces balance?...........

CHECK YOUR ANSWERS TO THIS GROUP OF QUESTIONS

1

(a) At rest.

Forces acting on the it are its weight force acting downwards and the reaction force from the building foundations acting upwards.

These forces balance.

(b) In uniform motion.

Forces acting on the it are its weight force acting downwards and the reaction force from the ice acting upwards. The vertical forces balance. There is no acceleration in the vertical direction.

There are no horizontal forces acting. The horizontal uniform motion is consistent with the absence of any horizontal force.

(c) In uniform motion.

Forces acting on it are the weight directed downwards and the air resistance directed upwards.

These forces balance. The motion of the leaf is not changing. It is travelling with a constant velocity.

(d) In uniform motion.

The vertical forces of weight and normal reaction from the road cancel.

The horizontal forces acting are:

(i) the force exerted by the car and transmitted through the towbar (similar to the tension in a rope) acting in the forward direction

(ii) the friction force exerted by the road on the tyres which is in the backwards direction.

These forces balance. The car is in uniform motion travelling with constant speed in a straight line i.e. the magnitude AND DIRECTION of the velocity are unchanging.

(e) This is not in uniform motion. Although the speed is constant the direction of motion is changing. The (vector) velocity is changing.

The only force acting on the satellite is the gravitational attraction (weight) directed towards the centre of the Earth.

This force is not balanced by any other and it is this which gives rise to the acceleration (change in vector velocity) of the satellite.

(f) This is not in uniform motion. Although the speed of the fly is constant its direction of motion is changing. The (vector) velocity is changing.

The only horizontal force acting on it is the force of friction acting on its feet. This force is directed towards the centre of the turntable.

This force is not balanced by any other and it is this which gives rise to the acceleration (change in vector velocity) of the fly.

The vertical forces acting on the fly (its weight and the normal reaction force from the turntable) are equal and opposite and cancel.

(g) This is not in uniform motion.

Once the ball has been kicked the only force acting on it (if we neglect air resistance) is the force of gravity (its weight).

This force is not balanced by any other and it is this which gives rise to the (downwards) acceleration of the football.

2

In the following questions assume:

The gravitational field strength g = 9.8 Nkg-1.

This is the force of attraction of the earth on an object of mass 1 kg.

A metal object hangs at rest on the end of a stretched coil spring which is attached to the ceiling. To keep things simple assume that the spring is weightless. The tension in the spring is

147 Newton.

(a) What is the magnitude and direction of the force exerted by the spring on the ceiling?

(b) What is the magnitude and direction of the force exerted by the spring on the object?

(c) What is the net force acting on the object?

(d) What is the weight of the object?

(e) If the object were released from the spring and allowed to fall what would be the net force acting on the object?

(f) What is the mass of the object?

(g) With what acceleration will the object fall?

(h) While the object is falling what is its weight?

CHECK YOUR ANSWERS TO THIS GROUP OF QUESTIONS

2

(a) 147 Newton downwards. A stretched spring exerts forces on whatever is attached to its ends. The magnitude of the force is the tension in the spring. Since the spring is stretched the force is directed towards the centre of the spring, downwards in this case.

(b) 147 Newton upwards. As stated above, a stretched spring exerts forces on whatever is attached to its ends, the force being directed towards the centre of the spring, upwards in this case.

(c) 0 Newton. Since the object is at rest the net force acting on it is zero.

(d) 147 Newton. This is the downward gravitational force exerted by the earth on the body. It is opposed by the equal and opposite force exerted by the spring. If you gave the answer 15 kg. you would have been quoting the mass of the object, the answer to Question (f). ALWAYS remember that the weight of a body is the gravitational force exerted on the body by the earth. BE CAREFUL TO DISTINGUISH BETWEEN MASS AND WEIGHT. Although the word "weight" is often used loosely in everyday speech it is important in Physics to reserve this word for the gravitational force exerted on a body by the earth. Do not use it as a substitute for the word "mass".

(e) 147 Newton. This is the gravitational force exerted on the object by the earth. This force is always present for bodies on or near the earth. This is the only force acting on the falling body, assuming that there is no air resistance.

(f) 15 kg. Since g = 9.8 Nkg-1 the weight of an object of mass 1 kg is 9.8N.

The mass m of an object of weight W is



1

(g) 9.8 ms-2. This is a simple application of Newton's Law F = ma where F is in Newton, a is in ms-2 and m is in kg. Note that all bodies at the surface of the earth subject ONLY to the force of gravity will fall with this acceleration. In this case, the net force F acting on the body is its weight m(kg)g(Nkg-1) =mg Nand using Newton's Second Law F = ma gives

a = F/m = g = 9.8 Nkg-1 = 9.8 ms-2.

Note the alternative but equivalent form of units Nkg-1 or ms-2.

(h) 147 Newton. This is the same question as (e). When a body is falling the earth is still exerting a gravitational force on the body and this is its weight. You may have given the answer 0 Newton to this question because of what you have read about "weightlessness in satellites, space stations and vehicles in "free fall". This can cause great confusion because in these cases the word "weight" is again being used loosely to mean the reading on a platform scale of the type on which you "weigh" yourself. It is safest to reserve the word "weight" for the gravitational force exerted on a body by the earth. When you stand on the scales in your bathroom, the scale reading will correspond to your weight, but if you do this in an elevator which is accelerating up or down you will get very different readings, which will not be your weight as defined in terms of gravitational force.

This situation is discussed in the next question.

3



1

In this question you are asked to consider the situation in an elevator containing a block sitting on a set of bathroom platform scales. The scales measure a force, the reaction force exerted by the block on the scale and the dial is calibrated in Newtons.

The question involves the following quantities:

g = the gravitational field strength

= 9.8 Nkg-1.

This is the force of attraction of the earth on an object of mass 1 kg or the acceleration due to gravity at the earth's surface.

m = mass of block = 6 kg.

a = acceleration of the block in ms-2. (Take the upwards direction as positive)

F = net (total or resultant) force on block in Newton. (Take the upwards direction as positive)

W = weight of block in Newton. This is a downwards force as shown in the diagram.

R = reaction force exerted by the scale on the block in Newton. This is an upwards force as shown in the diagram.

S = scale reading in Newton =reaction force exerted by the block on the scale

You should fill in the following table for the various conditions listed in the left hand column. Be careful with the sign of F and how it relates to R and W.

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| The elevator: | a ms-2 | F Newton | W Newton | R Newton | S Newton |
| a) is at rest |  |  |  |  |  |
| b) has a constant velocity of 5 ms-1 upwards. |  |  |  |  |  |
| c) has a constant velocity of 5 ms-1 downwards |  |  |  |  |  |
| d) has an acceleration of 5 ms-2 upwards. |  |  |  |  |  |
| e) has an acceleration of 5 ms-2 downwards. |  |  |  |  |  |
| f) is in free fall |  |  |  |  |  |

CHECK YOUR ANSWERS TO THIS GROUP OF QUESTIONS

3

The main features which you should have used in answering this question are:

i) The acceleration a of the block is of course the same as the acceleration of the elevator.

ii) The net force F on the block is given by F = ma and the sign of F will depend on the sign of a.

iii) F, R and W are related by F = R - W, remembering that R is measured upwards and W downwards and F may be positive or negative depending on a.

iv) The scale reading S is a measure of the force exerted on the scale by the block and by Newton's Third Law this is numerically equal to R and in the opposite direction. The scale reading is, as on your bathroom scales a positive one!

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| The elevator: | a ms-2 | F(up) Newton | W Newton | R Newton | S Newton |
| a) is at rest | 0 | 0 using F = ma | 6g  = 58.8 | 58.8 since F= R-W | 58.8 S and R are equal |
| b) has a constant velocity of 5 ms-1 upwards. | 0 | 0 using F = ma | 58.8 | 58.8 | 58.8 |
| c) has a constant velocity of 5 ms-1 downwards | 0 | 0 using F = ma | 58.8 | 58.8 | 58.8 |
| d) has an acceleration of 5 ms-2 upwards. | +5 where "up" is +ve | +30 using  F = ma where "up"is positive | 58.8 | 88.8 since F= R-W | 88.8 |
| e) has an acceleration of 5 ms-2 downwards. | -5 | -30 using  F = ma | 58.8 | 28.8 | 28.8 |
| f) is in free fall | -9.8 | -58.8 using  F = ma | 58.8 | 0 | 0 |

These examples show quite clearly that the bathroom scales only measure the weight of the block when the elevator is at rest or moving with constant velocity. In particular when the elevator is in free fall the scale reading is zero. It is in situations like this that the term "weightlessness" is used. This is an unfortunate term and should be avoided. The term "weight" should be used only for the gravitational force exerted on a body.

4



2

The figure shows a block of weight W Newton in three situations. In A it is hanging on a string, in B it is resting on a compression spring which is sitting on the floor and in C it is sitting directly on the floor. In all cases the block is at rest.

(a) For case A describe in words the nature of the force which opposes the weight W:

(b) For case B describe in words the nature of the force which opposes the weight W:

(c) For case C describe in words the nature of the force which opposes the weight W:

The next part of the question is concerned with Newton's Third Law which is often stated "For every action there is an equal and opposite reaction".

Regarding the weight W of the block as the "action" force describe in words the nature of the "reaction" force for:

(d) case A

(e) case B

(f) case C

CHECK YOUR ANSWERS TO THIS GROUP OF QUESTIONS

4

(a) The force exerted by the string usually called the "tension in the string". This is the type of force which you feel when you stretch a rubber band. The topic of tension will be discussed in Question 5.

(b) The force exerted by the compressed spring. This is the type of force which you feel when you squash a tennis ball. Both this and the tension force of question (a) are associated with the deformation (change of shape) of a solid material.

(c) The force exerted by the floor. Case C is very similar to case B. In case C the floor will squash down under the weight of the block in much the same way as the spring in case B or the squashed tennis ball. The movement of the floor however will be very small and not usually noticeable. This small deformation will however have a force associated with it and this is often called the normal reaction force. Such forces are present when two bodies are in contact. Note that here the word "normal" means "perpendicular" not "usual".

(d) The gravitational force exerted BY the block ON the earth. You must remember that the "action-reaction" pair of Newton's Third Law involve only two bodies, let's call them X and Y. If the "action force" is the force exerted by body X on body Y then the "reaction force" is the force exerted by body Y on body X. In this case we are considering the "action force" is the weight of the block ie the gravitational force exerted by the earth on the block. The two bodies involved are the earth and the block. The "reaction force" is therefore the gravitational force exerted by the block on the earth.

(e) The gravitational force exerted BY the block ON the earth. This is exactly the same situation as the previous question. The two bodies involved are the block and the earth.

(f) The gravitational force exerted BY the block ON the earth. This is exactly the same situation as the two previous questions. The two bodies involved are the block and the earth.

You may have answered this question by saying that the "reaction force" was the force exerted by the floor on the block. This is a common error since the term "normal reaction force" is used to describe this force and the term "reaction" is used in the usual statement of Newton's Third Law. Read the Interlude below. It will assist you with this difficulty.

INTERLUDE: NEWTON'S THIRD LAW

The statement of Newton's Third Law as "To every action there is an equal and opposite reaction" is to be avoided. It is best to say "If one object exerts a force on a second object then the second object will exert an equal and opposite force on the first". This will keep you out of trouble!

Remember that only two objects are involved in Newton's Third Law. It is useful to think about many examples of "action-reaction pairs" which illustrate the general nature of the Third Law.

A horse pulling a cart and the cart pulling back on the horse.

A racquet driving a ball forwards and the ball exerting a backward force on the racquet.

Two cars in collision exerting equal and opposite forces on each other at any instant

A block exerting a force on a table on which it is resting and the table exerting an equal and opposite force on the block.

A magnet exerting an attractive force on a pin and the pin attracting the magnet with an equal force.

An electrically charged comb attracting a small piece of paper and the paper attracting the comb with an equal force.

The earth attracting a falling apple and the apple attracting the earth with an equal force.

In these last three cases the reaction force is not obvious to us since one of the objects (magnet, comb or earth) has a much larger mass than the other (pin, paper or apple). The effect of the force on the massive object is difficult to observe or measure. Remember that with F = ma, if m is large then a is small.

5



3

It is well known that forces can be transmitted through bodies, for instance if a rope is pulled with a force F, this force is transmitted to the wall to which the rope is tied as shown in the upper figure. It is usual to say that the rope exerts a tension force F on the wall. The tension at the end of the rope is the force with which the rope pulls on whatever it is attached to.

The lower diagram shows a schematic situation in which the section AB of the rope is imagined to be "isolated" from the wall and the rest of the rope. As indicated in this diagram a force F directed to the right is acting on the wall.

You are required to draw force vectors at A, B and B′ representing the magnitude and direction of the force on the "cut" surface of the rope and to give the reason for your choice.

The reason for my choice of the vector at A is:

The reason for my choice of the vector at B is:

The reason for my choice of the vector at B′ is:

CHECK YOUR ANSWERS TO THIS QUESTION5



4

The reason for the choice of the vector at A is:

The rope exerts a force F to the right on the wall. Therefore by Newton's Third Law the wall must exert an equal and opposite force on the rope i.e. F to the left.

The reason for the choice of the vector at B is:

The section of rope AB is at rest. Therefore there must be zero net force acting on it. The force at B must therefore be equal and opposite to the force at A i.e. F to the right.

The reason for the choice of the vector at B′ is:

The force at B is the force exerted on the left hand portion of the rope AB by the right hand portion B′C. By Newtons Third Law the force at B′, the force exerted on B′C by AB will be equal and opposite to this i.e. F to the left.

INTERLUDE: TRANSMISSION OF TENSION FORCES



5



6

If we now imagine the rope "joined together" again at B it is easy to imagine as shown in the figure that there are equal and opposite forces acting on the two pieces on either side of the cut and one uses the word "tension" to describe the magnitude of the force acting on either piece. This tension is present at all places along the rope (there is nothing special about the place where we made our "imaginary cut' B). Thus we speak of the tension "in the rope" or "transmitted through the rope".

It is helpful to think about how the tension is transmitted along a rope or wire. Think of a wire as a regular arrangement of atoms each linked to their neighbours by interatomic bonds, represented by springs in the figure. If a force is applied to one end of the wire the other end being kept fixed, this applied force will be transmitted along the wire by the "interatomic springs". The springs will extend in the direction of the applied force and the wire will become slightly longer. In this way the force is transmitted so that a force F is exerted on the wall at the left hand end. Of course, by Newton's Third Law the wall will exert a force F to the left on the wire.

6



7

The figure shows a string passing over smooth pulleys with weights attached to each end. What is the tension in the string?

7

Imagine a rather artificial situation in which you strike a ball and exert a constant force F for a short period Δt. The product FΔt ,called the impulse, is a measure of how long and how hard you hit the ball.

The magnitude of the Impulse FΔt is most closely related to:

A The acceleration of the ball

B The change in direction of motion of the ball

C The change in kinetic energy of the ball

D The change in momentum of the ball

Give your reasons why the other answers are incorrect.

CHECK YOUR ANSWERS TO THE LAST TWO QUESTIONS

8

Consider an object of mass 2 kg initially at rest which is acted on by a constant force of 15 N for a period of 2 s.

(a) What is the impulse of this force?

(b) What is the speed of the object at the end of the 2 s period?

9

Consider an object of mass 2 kg "colliding" (i.e. interacting) with a device which exerts a constant force of 20 N on it for a period of 4 s.

(a) What is the magnitude of the impulse of this force?

(b) If the initial velocity of the object was +50 m s-1 and the force was negative (i.e.in the direction opposite to the initial direction of motion), what is the velocity of the object after the collision?

(c) If the initial velocity of the object was +15 ms-1 and the force was in the direction opposite to the initial direction of motion, what is the velocity of the object after the collision?

CHECK YOUR ANSWERS TO THE LAST TWO QUESTIONS

6



8

15 N. As far as the string is concerned this situation is no different from the cases shown in the figure, the free end of a string attached to a wall being pulled with a force of 15 N or a string being pulled at both free ends with a force of 15 N. Remember that since the string or any portion of it is at rest there must be equal and opposite forces on each end of it.

7

D. This follows from the relation FΔt = m(vf - vi), where vi and vf are the initial and final velocities respectively and the product mv defines momentum.

A is incorrect since the acceleration a at any instant is determined by the instantaneous value of F only via Newton's Second Law F = ma.

B is incorrect. When an impulse acts on the ball the direction of motion is not necessarily changed, for example when a ball is caught.

C is incorrect. Although a change in kinetic energy is often associated with an impulse this is not necessarily the case. An example is a ball rebounding from a wall, striking the wall with a velocity +v and leaving the wall with a velocity -v. In this case the kinetic energy (= ½mv2) is unchanged.

8

(a) The magnitude of the impulse is FΔt = 30 N s = 30 kg m s-1.

Note the alternative but equivalent form of units, N s corresponding to force × time and kg m s-1 corresponding to mass × velocity i.e. momentum.

(b) 15 m s-1. The impulse of 30 N s causes a change in momentum m(vf - vi), where vi and vf are the initial and final velocities respectively.

Thus 30 = 2(vf - 0) and vf = 15 m s-1.

9

(a) The magnitude of the impulse is FΔt = 80 N s = 80 kg m s-1.

Note the alternative but equivalent form of units, N s corresponding to force × time and kgms-1 corresponding to mass × velocity i.e. momentum.

Note that the word "interaction" was used as an alternative to "collision". It is not necessary that a "collision" should be a short sharp process. The "collision" of a space craft with a planet may involve a spell in the planet's gravitational field and not a crash on the planet's surface.

(b) +10 m s-1. The impulse is -80 N s and this causes a change in momentum m(vf - vi), where vi and vf are the initial and final velocities respectively.

Thus -80 = 2(vf - 50) and vf = +10 m s-1.

Here the impulse has opposed the motion and slowed down the ball.

(c) -25 m s-1. The impulse of -80 N s causes a change in momentum m(vf - vi).

Thus -80 = 2(vf - 15) and vf = -25 m s-1.

Here the impulse has opposed the motion and caused the ball to reverse its direction of motion and leave the device with an increased speed.

This example was a simple one-dimensional situation. Later you will study two dimensional situations in which impulse and momentum are both treated as vectors.

10



9

Immediately after being kicked a football of mass m is moving through the air as shown. The instantaneous velocity **v** and acceleration **a** vectors are shown.

In addition to the weight force **W** which of the following are forces acting on the projectile?

A A friction force due to air resistance acting in the direction of -**v**.

B A driving force in the direction of +**v**.

C A Newtonian force **F** of magnitude ma in the direction of the acceleration vector **a**.

D A residual force in the initial direction of travel resulting from the impulse of the kick.

ANS

11



10

A lift is moving upwards with acceleration a.

Which of the following forces are acting on a block of mass m sitting on the floor of the lift?

A An accelerating force of magnitude ma in the direction of the acceleration vector **a**.

B An upward force exerted by the floor on the block.

C The weight mg of the block.

D The gravitational force exerted by the block on the earth.

12

A coin of mass m is flicked across a horizontal table. After being flicked the forces acting on the coin will be

A The weight of the coin acting vertically down

B A residual force due to the impulse exerted by the flick.

C A normal reaction force exerted by the table on the coin acting vertically upwards.

D A force associated with the motion and equal to ma where a is the instantaneous value of acceleration of the coin.

E A frictional force opposite to the direction of motion of the coin.

CHECK YOUR ANSWERS TO THIS GROUP OF QUESTIONS10

A is the only correct response.

B,C and D are all incorrect. No force is required to "drive" the ball along (Response B). Forces only change motion they are not necessary to sustain motion.

D is incorrect since once the football has left the player's boot there is no force acting on the ball due to the kick.

C is incorrect. Newton's Second Law **F** = m**a** allows you to calculate the acceleration of a body if you know the net force acting on it. The **F** in Newton's Law is NOT a single physical force acting on the body. It is the resultant (sum) of all the forces acting. This point is often misunderstood and it is essential that you do not treat the quantity m**a** in the same way as "real" forces such as weight, friction etc..

11

B and C are the correct responses.

D is incorrect since it is a force acting on the earth, not on the block.

As explained in the previous question A is incorrect. The block is certainly accelerating but it does not require a separate force for this. The resultant of the forces described in B and C determine the acceleration of the block using Newton's Law **F** = m**a** where **F** is the net or resultant force on the block.

12

A, C and E are the correct responses. A and C are equal and opposite and therefore cancel out and this is consistent with the fact that the coin has no vertical component of its motion. The only other force acting on it is friction which will be slowing it down, the (negative) acceleration being given by Newton's Law in the form:

Net force = Friction force = ma

B is incorrect. A force is exerted only during the "flick" and this accelerates the coin until the coin has left the finger. After this the coin is "on its own". The finger exerts no further influence on it. There is no residual effect.

D is incorrect. As explained in earlier questions the force **F** in **F** = m**a** is not a separate force but the resultant of all the forces acting on a body.

13



11

John pulls on a rope to move a sled of mass m across rough horizontal ground with acceleration **a**.

Which of the following are forces acting on the sled?

A The force which John exerts on the rope.

B The weight of the sled.

C The tension in the rope acting on the sled.

D A friction force due to the rough ground.

E A vector force **F** = m**a** necessary to keep the sled accelerating.

F A vertical force exerted by the ground on the sled.

14

A beetle of mass 0.05 kg stands on a record player turntable rotating at constant speed.

(a) If the friction force on the feet of the beetle is 0.008 Newton what is the acceleration of the beetle?

ANS

(b) What is the direction of the acceleration vector?

ANS

(c) The beetle is travelling with constant speed. Explain how it is accelerating.

ANS

CHECK YOUR ANSWERS TO THIS GROUP OF QUESTIONS

15

A block of mass 6 kg is being pulled by a rope across a rough floor. The rope and the floor are both horizontal. A frictional force of 3 N acts on the block and the acceleration of the block is 2 ms-2.

(a) What is the net force on the block?

ANS

(b) What is the tension in the rope?

ANS

CHECK YOUR ANSWERS TO THIS GROUP OF QUESTIONS

13

B, C, D and F are the correct responses. Note that C is the force exerted by the rope on the sled is the correct response and not A which is the force exerted on the rope by John. This force is certainly transmitted by the rope but it is the rope which pulls directly on the sled not John.

E is incorrect. Certainly a force is necessary to keep the sled accelerating but this in not a separate force but rather a resultant of all the forces acting.

14

(a) 0.16 ms-2. The only horizontal force acting on the beetle is the friction force acting on its feet. Application of Newton's Second Law F = ma yields

a = 0.16 ms-2.

(b) Towards the centre of the turntable. The friction force **F** on the beetle's feet is directed towards the centre of the turntable. Remember that Newton's Law is a vector equation

**F** = m**a**.and **a** is in the same direction as **F**.

(c) Remember that acceleration is related to change in velocity. In this situation the velocity is certainly changing. Although the magnitude of the velocity (i.e. the speed) is constant, the direction of the velocity vector is changing.

15

(a) 12 N. This is given by the relation F = ma where F is the net force on the body.

(b) 15 N. There are only two horizontal forces acting on the block, the tension in the rope T and the frictional force of 3 N. These are oppositely directed and so the net force is T - 3 which we saw in part (a) was 12 N.

16

In tackling this question you may find it helpful to draw simple diagrams showing the forces on the lift and the direction of its acceleration. In fact you should get into the habit of drawing diagrams wherever possible. They will aid you in "picturing "the situation.

A lift of weight 1.96 × 104 N suspended by a cable is accelerating upwards at 4 ms-2.

(a) What is the net force acting on the lift?

ANS

(b) What is the tension in the lift cable?

ANS

(c) If the lift is accelerating downwards at 4 ms-2 what is the net force acting on the lift?

ANS

(d) What is the tension in the lift cable?

ANS

(e) If the lift is travelling downwards at a constant velocity of 10 ms-1 what is the net force acting on the lift?

ANS

(f) What is the tension in the lift cable?

ANS

CHECK YOUR ANSWERS TO THIS GROUP OF QUESTIONS16

(a) 8000 N upwards.

The net force is equal to ma where m is the mass of the lift which should NOT be confused with its weight.

The weight of the lift is the gravitational force on it which is equal to mg where m is the mass and g = 9.8 ms-2.

m is therefore 2000 kg and F = ma is 4 × 2000 = 8000 N.

(b) 2.76 × 104. The net upwards force on the lift is T - 19600 = 8000 and therefore T = 27600 N.

(c) 8000N downwards. Since a is downwards the net force ma must be downwards.

(d) 1.16 × 104. The net downward force on the lift is 19600 - T = 8000 and therefore T = 11600 N.

(e) 0 N. The lift is travelling with constant velocity. Its acceleration is zero and so the net force on it must be zero.

(f) 19600 N. Since the net force is zero, the upwards tension force must be equal to the weight force.

17



12

Two railway trucks A and B equipped with spring buffers collide. The masses and velocities of the trucks are as shown in the diagram.

(a) At the first instant of collision the magnitude of force exerted by truck A on truck B will be ....................(greater than, less than, equal to ) the magnitude of the force exerted by truck B on truck A.

(b) At later times during the collision the magnitude of the force exerted by truck A on truck B will be ....................(greater than, less than, equal to ) the magnitude of the force exerted by truck B on truck A.

(c) The magnitude of the impulse on A during the whole collision process will be ..................(greater than, less than, equal to ) the magnitude of the impulse on B.

(d) What is the momentum of truck A before the collision?

(e) What is the momentum of truck B before the collision?

(f) What is the total momentum of the system before the collision?

ANS

(g) The ratio



is:

A equal to 1 only if the collision is elastic

B always less than 1

C greater than, equal to or less than 1 depending on how much mechanical energy is lost in the collision.

D always equal to 1

E equal to zero if the trucks lock together during collision

F equal to or less than 1 depending on how much mechanical energy is lost in the collision.

ANS...........(One or more answers)

CHECK YOUR ANSWERS TO THIS GROUP OF QUESTIONS

17

(a) Equal to. This follows from Newton's Third Law. The force which body A exerts on body B is equal to that exerted by body B on body A.

(b) Equal to. Newton's Third Law is always true. At any time the force which body A exerts on body B is equal to that exerted by body B on body A.

(c) Equal to. Since the magnitude of the forces are equal at any instant, the magnitude of the impulses F.Δt during any time interval Δt will be equal. Hence the magnitude of the impulses over any extended time period will be equal.

(d) 1.5 × 105 kg m s-1 to the right.

Momentum = mass × velocity = 3000 kg × 50 ms-1.

(e) 2 × 104 kg m s-1 to the left.

Momentum = mass × velocity = 2000 kg × 10 ms-1.

(f) 1.3 × 105 kg m s-1 to the right.

(g) D. Momentum is always conserved in a collision, provided that there are no external forces acting. Since the internal forces are equal and opposite {questions (a) and (b)} the impulses are equal and opposite and hence the change in momentum of each of the trucks are equal and opposite. Although mechanical energy may be lost in a collision, momentum is always conserved.