PHYSICAL SCIENCES

MATERIAL FOR GRADE 12

GRADE 11 WORK

NEWTON'S LAWS OF MOTION

QUESTIONS

COMPILED BY EXPERTS: K. NCUBE & T. MJIKWA

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➢ MECHANICS: NEWTON'S LAWS

Static frictional force: The force that opposes the tendency of motion of a STATIONARY object relative to a surface.

Kinetic frictional force: The force that opposes the motion of a MOVING object relative to a surface.

Maximum static frictional force: The static frictional force is a maximum just before the object starts to move across the surface.

Free-body diagrams: This is a diagram that shows the relative magnitudes and directions of forces acting on a body/particle that has been isolated from its surroundings

Newton's first law of motion: A body will remain in its state of rest or motion at constant velocity unless a non-zero resultant/net force acts on it.

Inertia: The resistance of a body to a change in its state of uniform motion or to rest.

Mass: is a measure of an obejct's inetia.

Newton's second law of motion: When a resultant/net force acts on an object, the object will accelerate in the direction of the force at an acceleration directly proportional to the force and inversely proportional to the mass of the object.

In symbols: $F_{net} = ma$

Newton's Third Law of motion: When object A exerts a force on object B, object B SIMULTANEOUSLY exerts a force equal in magnitude but opposite in direction on object A.

Newton's Law of Universal Gravitation: Each body in the universe attracts every other body with a force that is directly proportional to the product of their masses and inversely proportional to the square of the distance between their centres.

Normal force: Define N as the force or the component of a force which a surface exerts on an object with which it is in contact, and which is perpendicular to the surface.

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Mass: The amount of matter in a body measured in kilogram (kg).

Weight: The gravitational force, in newton (N), exerted on an object.

Weightlessness: The sensation experienced when all contact forces are removed i.e. no external objects touch one's body.

➢ FORCES

- ✓ **Different kinds of forces:** weight, normal force, frictional force, applied force (push, pull), tension (strings or cables).

➢ OBJECT RESTING ON A HORIZONTAL SURFACE.

- ✓ When an object is resting or moving on a horizontal surface the normal force will have the same magnitude, but an opposite direction to the weight of the object or gravitational force.

➢ OBJECT RESTING ON AN INCLINED SURFACE

- ✓ When an object is resting or moving on an inclined plane (surface), the normal force will have the same magnitude, but an opposite direction to the perpendicular component of the weight of the object or gravitational force.

➢ KNOW THAT A FRICTIONAL FORCE

- ✓ Is proportional to the normal force
- ✓ Is independent of the area of contact
- ✓ Is independent of the velocity of motion
- ✓ Solve problems using fs= μsN, where is the maximum static frictional force and μs is the coefficient of static friction.

KUTHI HUUUUUUU!!!!!!

- ✓ If a force, F, applied to a body parallel to the surface does not cause the object to move, F is equal in magnitude to the static frictional force.
- ✓ The static frictional force is a maximum ( ) just before the object starts to move across the surface.
- ✓ If the applied force exceeds, a resultant/net force accelerates the object.
- ✓ Solve problems using fk = μkN, where fk is the kinetic frictional force and μk the coefficient of kinetic friction.

NEWTON'S FIRST, SECOND AND THIRD LAWS OF MOTION

- **State Newton's first law of motion**:

  A body will remain in its state of rest or motion at constant velocity unless a non-zero resultant/net force acts on it. Discuss why it is important to wear seatbelts using Newton's first law of motion.

- **State Newton's second law of motion:**

When a resultant/net force acts on an object, the object will accelerate in the direction of the force at an acceleration directly proportional to the force and inversely proportional to the mass of the object.

- **State Newton's third law of motion:**

When one body exerts a force on a second body, the second body exerts a force of equal magnitude in the opposite direction on the first body.

- ✓ Identify action-reaction pairs.
- ✓ List the properties of action-reaction pairs.

- **Newton's Law of Universal Gravitation**

State Newton's Law of Universal Gravitation: Each body in the universe attracts every other body with a force that is directly proportional to the product of their masses and inversely proportional to the square of the distance between their centres.

SOLVE PROBLEMS USING

- ✓ Calculate acceleration due to gravity on a planet using.
- ✓ Describe weight as the gravitational force the Earth exerts on any object on or near its surface.
- ✓ Calculate weight using the expression w = mg.
- ✓ Calculate the weight of an object on other planets with different values of gravitational acceleration.
- ✓ Distinguish between mass and weight.
- ✓ Draw force diagrams and free-body diagrams for objects that are in equilibrium or accelerating.
- ✓ Apply Newton's laws of motion to a variety of equilibrium and non-equilibrium problems including:

A SINGLE OBJECT:

- ✓ Moving on a horizontal plane with or without friction
- ✓ Moving on an inclined plane with or without friction
- ✓ Moving in the vertical plane (lifts, rockets, etc.)

➢ TWO-BODY SYSTEMS (JOINED BY A LIGHT INEXTENSIBLE STRING):

- ✓ Both on a flat horizontal plane with or without friction
- ✓ One on a horizontal plane with or without friction, and a second hanging vertically from a string over a frictionless pulley.
- ✓ Both on an inclined plane with or without friction
- ✓ Both hanging vertically from a string over a frictionless pulley
- ✓ Explain weightlessness.

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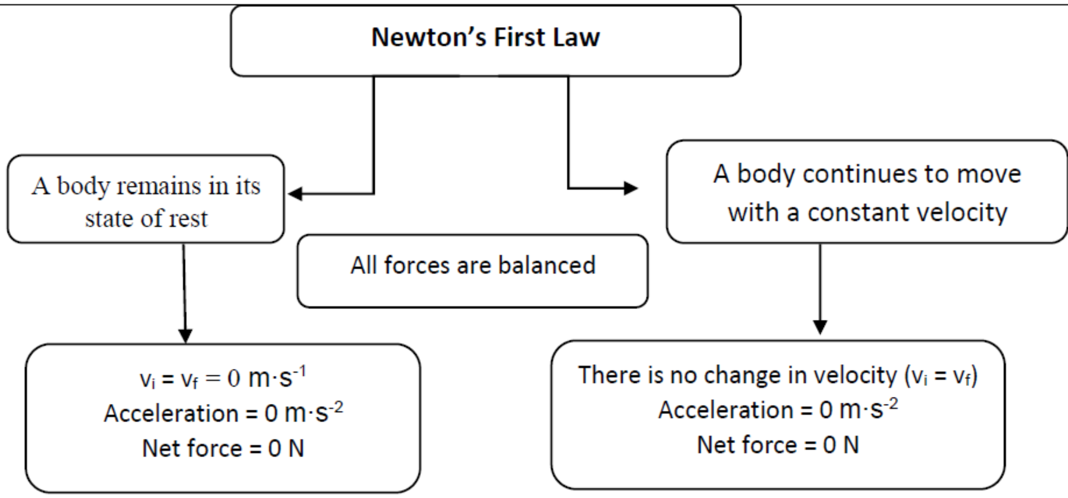
Newton's first Law of motion

A body will remain in its state of rest or motion at constant velocity unless a non-zero resultant/net force acts on it.



Inertia is the property of matter that keeps the object at rest to remain at rest and keeps moving objects moving. An object remains at rest due to its inertia and an object continues to move with a constant velocity due to its inertia. Larger masses have larger inertia, making them more difficult to move or to stop. An object's mass indicates its inertia.

Safety belts

We wear seat belts in cars. This is to protect us when the car is involved in an accident. If a car is travelling at 100 km·h^{-1}, the passengers in the car are also travelling at 100 km·h^{-1}. When the car suddenly stops a force is exerted on the car (making it slow down), but not on the passengers. The passengers will keep on moving forward at 100 km·h^{-1} due to inertia according to Newton's first law. The passengers will keep on accelerating at the same speed they were going in the car until something stops them, this could be the steering wheel, dashboard or the windshield. If they are wearing seat belts, the seat belts will stop them by exerting a force on them and so prevent them from getting hurt.

Newton's Second Law:

When a resultant/net force acts on an object, the object will accelerate in the direction of the force at an acceleration directly proportional to the force and inversely proportional to the mass of the object.

Newton's Second Law

↓

A net force acts on an object. $F_{net} \neq 0$ N
Forces acting on the object are not balanced

↓

Net force cause the object to accelerate in the direction of the force. Acceleration and net force are in the same direction.

There is a change in velocity ($v_i \neq v_f$)
$a \neq 0 \text{ m·s}^{-2}$

$F_{net} = ma$

$$a \; \alpha \; F_{net}$$

The greater the net force, the greater the acceleration. The smaller the net force, the smaller the acceleration

$$a \; \alpha \; \frac{1}{m}$$

The bigger the mass, the smaller the acceleration. The smaller the mass, the greater the acceleration.

NEWTON'S THIRD LAW

When object A exerts a force on object B, object B SIMULTANEOUSLY exerts an oppositely directed force of equal magnitude on object A.

Please note the following, regarding Newton's 3rd Law:

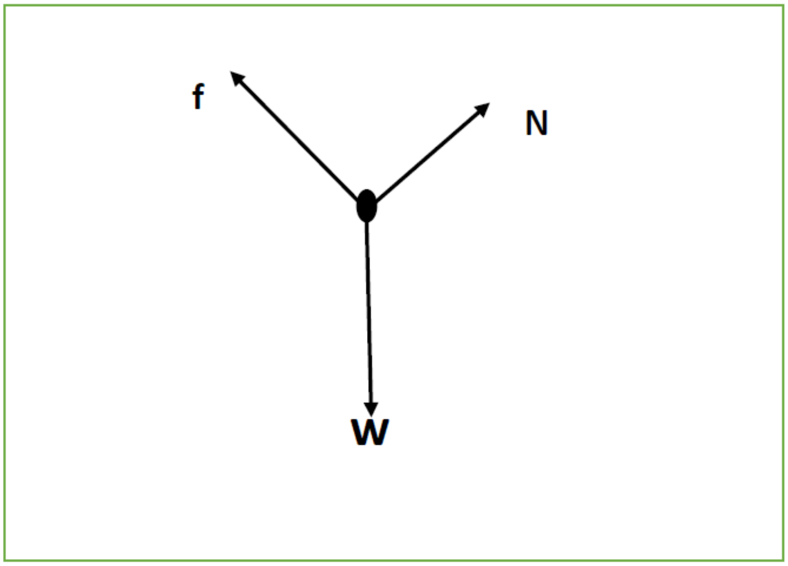
- In every interaction, there is a pair of forces acting on the two interacting objects.
- These forces are referred to as action-reaction pairs.
- The magnitude of the force on the first object equals the magnitude of the force on the second object.
- The direction of the force on the first object is opposite to the direction of the force on the second object.
- These forces are acting on separate objects.

Calculations in Physics

1. Indicate the choice of direction before starting a calculation.
2. Remember to include the direction (positive or negative sign) when substituting vectors in an equation.
3. Remember to interpret the sign obtained in the final answer of a calculation e.g. if east was chosen as positive, then a negative answer means the direction is west.
4. Use the same wording for direction as given in the question e.g. if west and east are used, give the direction in the final answer in terms of east or west.
5. Always draw a free body diagram before performing a calculation on Newton's second law and work-energy theorem. This will help you first identify the forces before attempting the calculation.
6.

Drawing of free body diagram

1. Draw a dot to represent the object
2. Starting on the dot, draw arrows to represent each force. Each arrow must start on the dot and has an arrow head.
3. The arrows must represent the direction of the forces.



Newton's laws and application of Newton's laws
(This section must be read in conjunction with the CAPS, p. 62–66.)

Different kinds of forces: weight, normal force, frictional force, applied force (push, pull), tension (strings or cables)

- Define normal force, N, as the force or the component of a force which a surface exerts on an object in contact with it, and which is perpendicular to the surface.
  NOTE: The normal force acts perpendicular to the surface irrespective of whether the plane is horizontal or inclined. For horizontal planes the only forces perpendicular to the plane should be the weight, w, and the normal force, N. All other forces should be parallel to the plane. For inclined planes the only forces perpendicular to the plane is the component of weight, $w\cos\theta$, and the normal, N. All other forces should be parallel to the plane.
- Define frictional force, f, as the force that opposes the motion of an object and which acts parallel to the surface.
  Know that a frictional force:
  - Is proportional to the normal force
  - Is independent of the area of the surfaces that are in contact with each other
- Define the static frictional force, f_s, as the force that opposes the tendency of motion of a stationary object relative to a surface. The static frictional force can have a range of values from zero up to a maximum value, $\mu_s N$. If a force, F, applied to an object parallel to the surface, does not cause the object to move, F is equal in magnitude to the static frictional force.

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- State that the static frictional force is a maximum, f_s^{max}, just before the object starts to move across the surface. The maximum static frictional force, f_s^{max}, is equal to the magnitude of the maximum horizontal force that can be applied to the object without it starting to move across the surface.
- Solve problems using $f_s^{max} = \mu_s N$ where f_s^{max} is the maximum static frictional force and μ_s is the coefficient of static friction. If the applied force exceeds f_s^{max}, a net force accelerates the object.
- Define the kinetic frictional force, f_k, as the force that opposes the motion of a moving object relative to a surface. The kinetic frictional force on an object is constant for a given surface and equals $\mu_k N$.
- Solve problems using $f_k = \mu_k N$, where f_k is the kinetic frictional force and μ_k the coefficient of kinetic friction.

Force diagrams, free-body diagrams

- Draw force diagrams. In a force diagram the force is represented by an arrow. The direction of the arrow indicates the direction of the force and the length of the arrow indicates the magnitude of the force.
- Draw free-body diagrams. Such a diagram shows the relative magnitudes and directions of forces acting on an object that has been isolated from its surroundings. The object is drawn as a dot and all the forces acting on it are drawn as arrows pointing away from the dot. The length of the arrows is proportional to the magnitude of the respective forces.
- Resolve a two-dimensional force, e.g. the weight of an object on an inclined plane, into its parallel ($F_{//}$) and perpendicular ($F_{\perp}$) components.
- Determine the resultant/net force of two or more forces.

Newton's first, second and third laws of motion

- State Newton's first law of motion: A body will remain in its state of rest or motion at constant velocity unless a non-zero resultant/net force acts on it.
- Define inertia as the resistance of an object to any change in its state of motion. The mass of an object is a quantitative measure of its inertia.
- Discuss why it is important to wear seatbelts using Newton's first law of motion.
- State Newton's second law of motion: When a resultant/net force acts on an object, the object will accelerate in the direction of the force at an acceleration directly proportional to the force and inversely proportional to the mass of the object.

  In symbols: $a \propto F_{net}$, constant m and $a \propto \frac{1}{m}$, constant F_{net}, and therefore $F_{net} = ma$
- Draw force diagrams and free-body diagrams for objects that are in equilibrium or accelerating.
- Apply Newton's second law of motion, and therefore, to a variety of equilibrium and non-equilibrium problems including:
  - A single object:
    - Moving in a horizontal plane with or without friction
    - Moving on an inclined plane with or without friction
    - Moving in the vertical plane (lifts, rockets, etc.)
  - Two-body systems (joined by a light inextensible string):
    - Both on a flat horizontal plane with or without friction
    - One in a horizontal plane with or without friction, and a second hanging vertically from a string over a frictionless pulley
    - Both on an inclined plane with or without friction
    - Both hanging vertically from a string over a frictionless pulley

NOTE: When an object accelerates, the equation $F_{net} = ma$ must be applied separately in the x and y directions. If there is more than one object, a free-body diagram must be drawn for each object and Newton's second law must be applied to each object separately.

- State Newton's third law of motion: When object A exerts a force on object B, object B SIMULTANEOUSLY exerts an oppositely directed force of equal magnitude on object A. (The forces are therefore an interaction between two bodies.)
- Identify Newton III force pairs (action-reaction pairs) and list the properties of the force pairs (action-reaction pairs). When identifying the forces it must be clearly stated which body exerts a force on which body, and what kind of force it is, e.g. the earth exerts a downward gravitational force on the object, and the object exerts an upward gravitational force of equal magnitude on the earth.

Newton's Law of Universal Gravitation

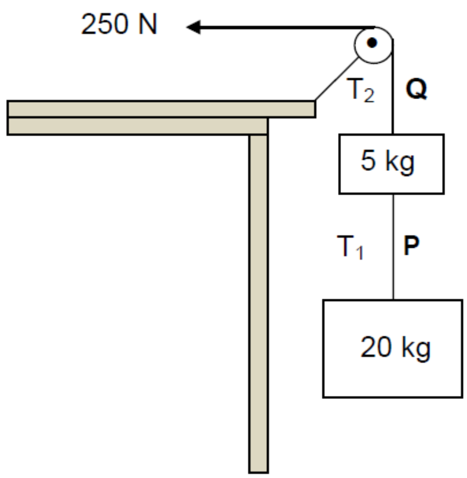
- State Newton's law of universal gravitation: Each particle in the universe attracts every other particle with a gravitational force that is directly proportional to the product of their masses and inversely proportional to the square of the distance between their centres.
- Solve problems using $F = \frac{Gm_1m_2}{r^2}$.
- Calculate acceleration due to gravity on the Earth using $g = \frac{GM}{r_E^2}$, and on another planet using $g = \frac{GM_p}{r_p^2}$ where M_p is the mass of the planet and r_p is the radius of the planet.
- Describe weight as the gravitational force, in newton (N), exerted by the Earth on an object. Describe mass as the amount of matter in a body measured in kilogram (kg).
- Calculate weight using the expression w = mg.
- Calculate the weight of an object on other planets with different values of gravitational acceleration.
- Explain weightlessness as the sensation experienced when all contact forces are removed, i.e. no external objects touch one's body. For example, when in free fall, the only force acting on your body is the force of gravity that is a non-contact force. Since the force of gravity cannot be felt without any other opposing forces, you would have no sensation of it and you would feel weightless when in free fall.

$F_{net} = ma$	$p = mv$
$f_s^{max} = \mu_s N$	$f_k = \mu_k N$
	$w = mg$
$F = G\frac{m_1m_2}{d^2}$ or/*of* $F = G\frac{m_1m_2}{r^2}$	$g = G\frac{M}{d^2}$ or/*of* $g = G\frac{M}{r^2}$

A

QUESTION 2 (Start on a new page.)

Two blocks of masses 20 kg and 5 kg respectively are connected by a light inextensible string, **P**. A second light inextensible string, **Q**, attached to the 5 kg block, runs over a light frictionless pulley. A constant horizontal force of 250 N pulls the second string as shown in the diagram below. The magnitudes of the tensions in **P** and **Q** are T_1 and T_2 respectively. Ignore the effects of air friction.



2.1 State Newton's Second Law of Motion in words. (2)

2.2 Draw a labelled free-body diagram indicating ALL the forces acting on the **5 kg block**. (3)

2.3 Calculate the magnitude of the tension T_1 in string **P**. (6)

2.4 When the 250 N force is replaced by a sharp pull on the string, one of the two strings break.

Which ONE of the two strings, **P** or **Q**, will break? (1)

[12]

B

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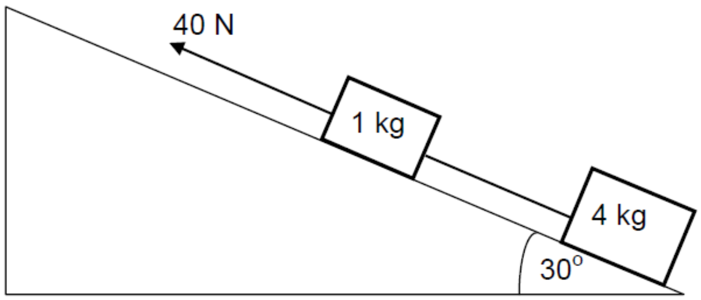
QUESTION 2 (Start on a new page.)

A block of mass 1 kg is connected to another block of mass 4 kg by a light inextensible string. The system is pulled up a rough plane inclined at 30° to the horizontal, by means of a constant 40 N force parallel to the plane as shown in the diagram below.



The magnitude of the kinetic frictional force between the surface and the 4 kg block is 10 N. The coefficient of kinetic friction between the 1 kg block and the surface is 0,29.

2.1 State Newton's third law in words. (2)

2.2 Draw a labelled free-body diagram showing ALL the forces acting on the **1 kg block** as it moves up the incline. (5)

2.3 Calculate the magnitude of the:

2.3.1 Kinetic frictional force between the 1 kg block and the surface (3)

2.3.2 Tension in the string connecting the two blocks (6)

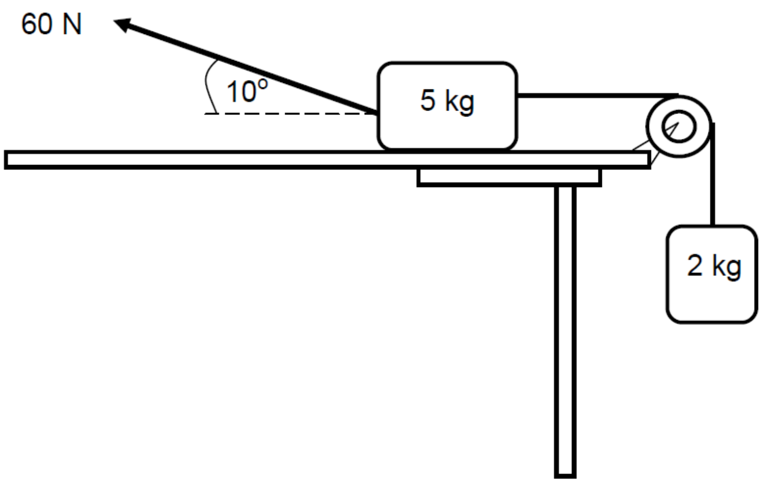
[16]

C

QUESTION 2 (Start on a new page.)

A 5 kg block, resting on a rough horizontal table, is connected by a light inextensible string passing over a light frictionless pulley to another block of mass 2 kg. The 2 kg block hangs vertically as shown in the diagram below.

A force of 60 N is applied to the 5 kg block at an angle of 10° to the horizontal, causing the block to accelerate to the left.



The coefficient of kinetic friction between the 5 kg block and the surface of the table is 0,5. Ignore the effects of air friction.

2.1 Draw a labelled free-body diagram showing ALL the forces acting on the 5 kg block. (5)

2.2 Calculate the magnitude of the:

2.2.1 Vertical component of the 60 N force (2)

2.2.2 Horizontal component of the 60 N force (2)

2.3 State Newton's Second Law of Motion in words. (2)

Calculate the magnitude of the:

2.4 Normal force acting on the 5 kg block (2)

2.5 Tension in the string connecting the two blocks (7)
[20]

D

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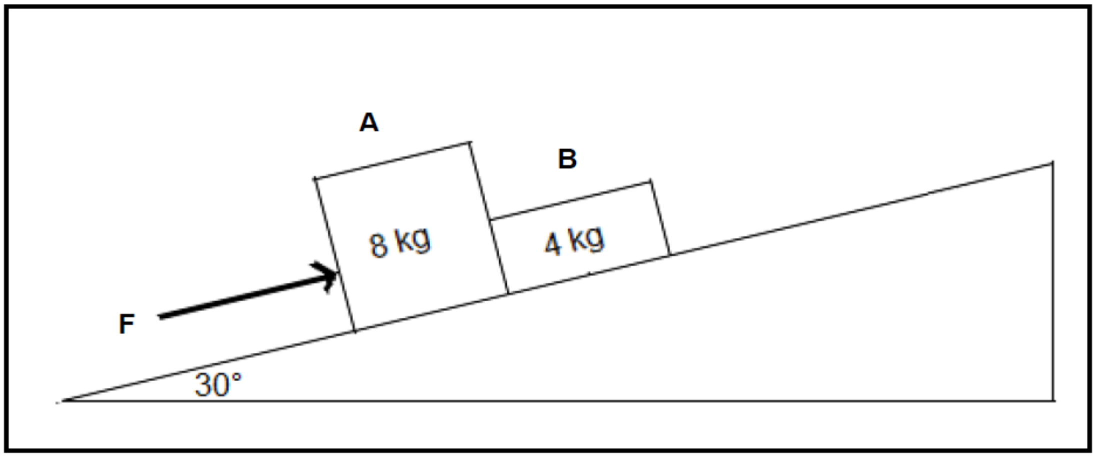
QUESTION 2 (Start on a new page.)

Two objects, **A** and **B**, of mass 8 kg and 4 kg respectively, are in contact. They lie on a plane inclined at 30° to the horizontal. A force, **F**, applied parallel to the incline, pushes on the objects as shown in the diagram below.



2.1 State *Newton's Second Law of motion* in words. (2)

The magnitude of kinetic frictional force acting on object **A** is 6,8 N and on object **B** is 3,4 N.

2.2 Draw a labelled free-body diagram of the forces acting on **B** as it moves up the inclined plane. (4)

2.3 Calculate the:

2.3.1 Magnitude of **F** if the system moves up the inclined plane at CONSTANT VELOCITY. (5)

2.3.2 Coefficient of kinetic friction for **B**. (3)

2.4 The angle between the incline and the horizontal changes to 35°.

2.4.1 How will the answer in QUESTION 2.3.2 be affected? Write down INCREASES, DECREASES or REMAIN THE SAME. (1)

2.4.2 How will the magnitude of the kinetic frictional force on object **B** be affected? Write INCREASES, DECREASES or REMAIN THE SAME. Explain your answer. (3)

[18]

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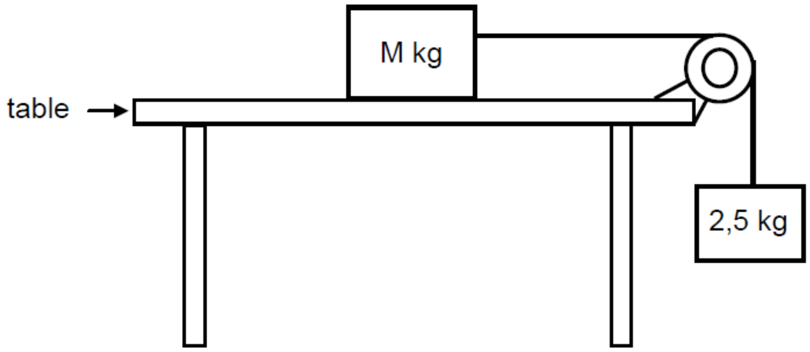
E

QUESTION 2 (Start on a new page.)

2.1 Two blocks of mass M kg and 2,5 kg respectively are connected by a light, inextensible string. The string runs over a light, frictionless pulley, as shown in the diagram below.

The blocks are **stationary**.



2.1.1 State Newton's THIRD law in words. (2)

2.1.2 Calculate the tension in the string. (3)

The coefficient of static friction (μ_s) between the unknown mass M and the surface of the table is 0,2.

2.1.3 Calculate the minimum value of M that will prevent the blocks from moving. (5)

The block of unknown mass M is now replaced with a block of mass 5 kg. The 2,5 kg block now accelerates downwards. The coefficient of kinetic friction (μ_k) between the 5 kg block and the surface of the table is 0,15.

2.1.4 Calculate the magnitude of the acceleration of the 5 kg block. (5)

2.2 A small hypothetical planet X has a mass of $6,5 \times 10^{20}$ kg and a radius of 550 km.

Calculate the gravitational force (weight) that planet X exerts on a 90 kg rock on this planet's surface. (4)

[19]

F

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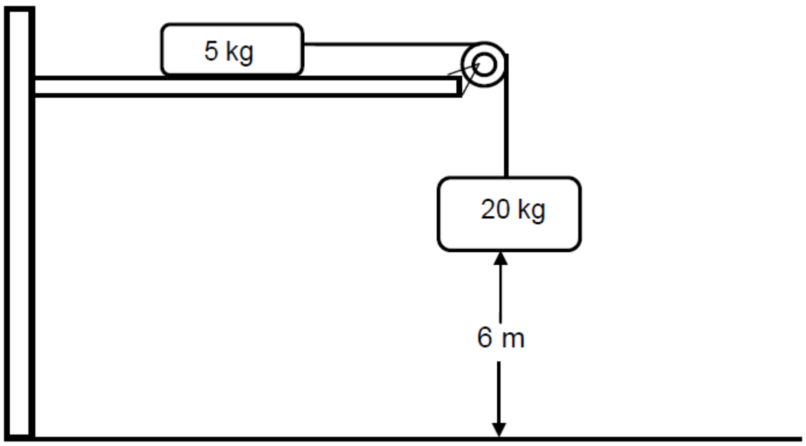
QUESTION 2 (Start on a new page.)

2.1 A 5 kg mass and a 20 kg mass are connected by a light inextensible string which passes over a light frictionless pulley. Initially, the 5 kg mass is held stationary on a horizontal surface, while the 20 kg mass hangs vertically downwards, 6 m above the ground, as shown in the diagram below.

The diagram is not drawn to scale.



When the *stationary* 5 kg mass is released, the two masses begin to move. The coefficient of kinetic friction, μ_k, between the 5 kg mass and the horizontal surface is 0,4. Ignore the effects of air friction.

2.1.1 Calculate the acceleration of the 20 kg mass. (5)

2.1.2 Calculate the speed of the 20 kg mass as it strikes the ground. (4)

2.1.3 At what minimum distance from the pulley should the 5 kg mass be placed initially, so that the 20 kg mass just strikes the ground? (1)

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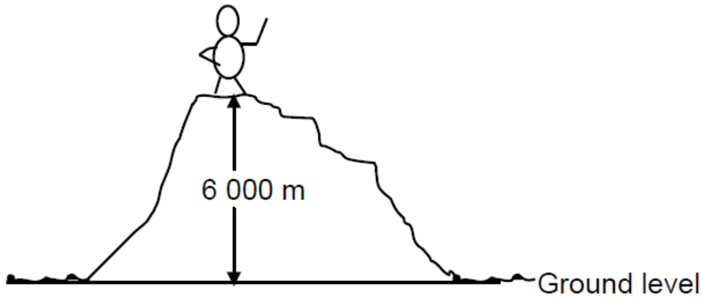
2.2 A person of mass 60 kg climbs to the top of a mountain which is 6 000 m above ground level.



2.2.1 State Newton's Law of Universal Gravitation in words. (2)

2.2.2 Calculate the *difference* in the weight of the climber at the top of the mountain and at ground level. (6)
[18]

G

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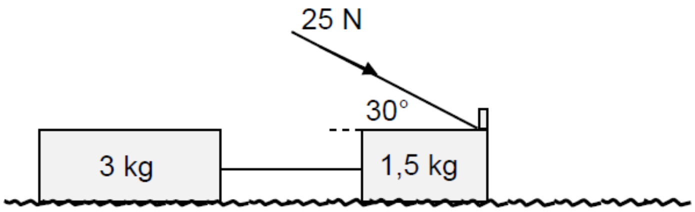
QUESTION 2 (Start on a new page.)

A learner constructs a push toy using two blocks with masses 1,5 kg and 3 kg respectively. The blocks are connected by a massless, inextensible cord.

The learner then applies a force of 25 N at an angle of 30° to the 1,5 kg block by means of a light rigid rod, causing the toy to move across a flat, rough, horizontal surface, as shown in the diagram below.



The coefficient of kinetic friction (μ_k) between the surface and each block is 0,15.

2.1 State Newton's Second Law of Motion in words. (2)

2.2 Calculate the magnitude of the kinetic frictional force acting on the 3 kg block. (3)

2.3 Draw a labelled free-body diagram showing ALL the forces acting on the 1,5 kg block. (5)

2.4 Calculate the magnitude of the:

2.4.1 Kinetic frictional force acting on the 1,5 kg block (3)

2.4.2 Tension in the cord connecting the two blocks (5)

[18]

H

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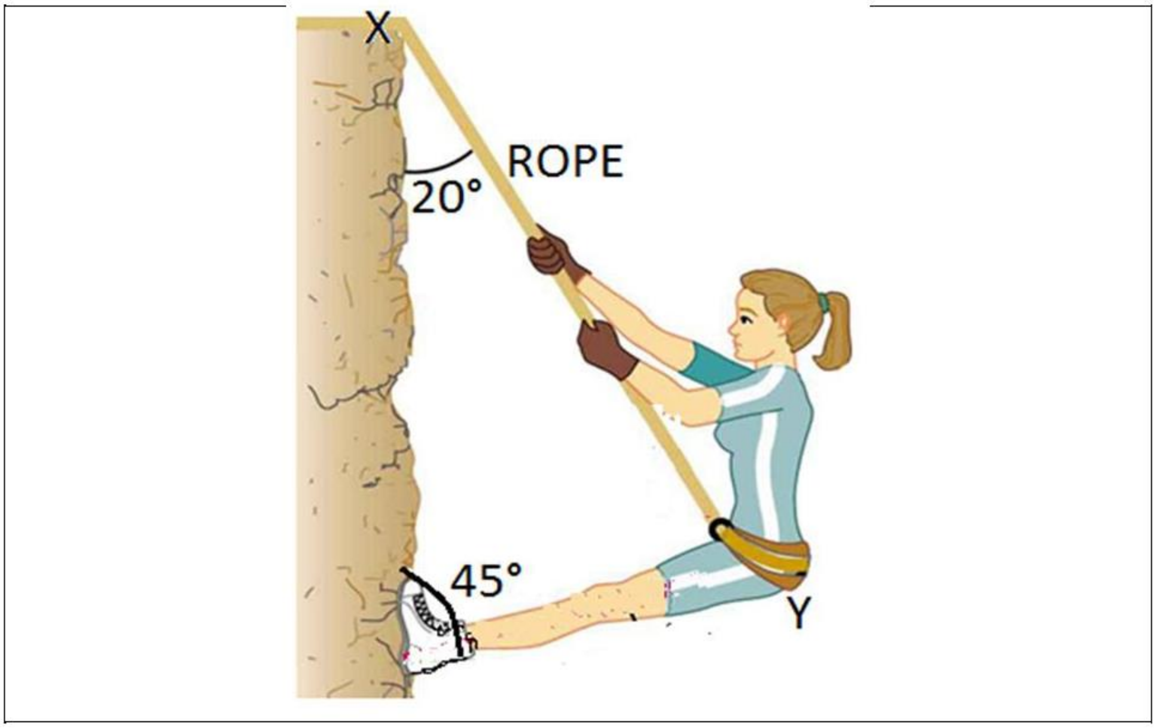
QUESTION 2 (Start on a new page.)

During a mountain climbing exercise, Ferial, mass 50 kg, is suspended from an inelastic piece of nylon rope, fixed to a vertical cliff at X on the cliff. She pushes her legs against the cliff so that they make an angle of 45° with the cliff, as indicated in figure. The angle that the rope makes with the cliff is 20°.



Point **Y** is in equilibrium.

2.1 Explain what is meant by Point Y *is in equilibrium.* (1)

2.2 Draw a FORCE DIAGRAM showing all the forces acting on point **Y.** (3)

2.3 Determine by means of ACCURATE CONSTRUCTION and MEASUREMENT. (use the scale 10 mm: 50 N and indicate at least TWO angles):

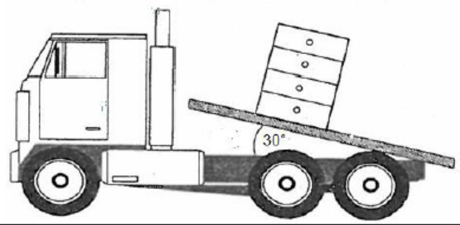
2.3.1 The magnitude of the force which the rope exerts on her.

2.3.2 The magnitude of the force exerted by her legs. (8)

[12]

QUESTION 3 (Start on a new page.)

A wooden cabinet of 60 kg rests on the back of a tip-up truck. The back tilts slowly, until it makes an angle of 30° with the horisontal. The cabinet does NOT move.



3.1 Calculate the magnitude of the frictional force. (3)

3.2 Calculate the coefficient of static friction. (3)

3.3 The angle of 30° is now increased. How will this change affect the following:

(Write down only INCREASES, DECREASES or REMAINS THE SAME)

3.3.1 The coefficient in QUESTION 3.2? (1)

3.3.2 The frictional force? Explain your answer. (3)

[10]

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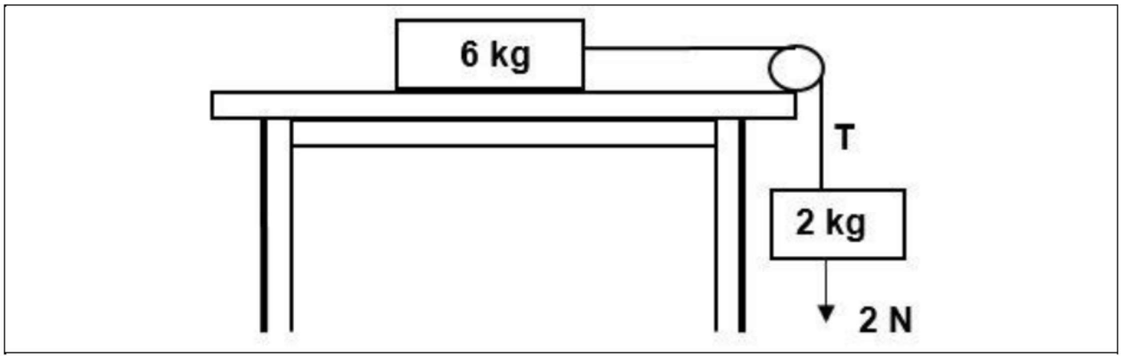
QUESTION 4 (Start on a new page.)

A 6 kg block on a horisontal rough surface is joined to a 2 kg block by a light, inelastic string running over a frictionless pulley. The frictional force between the 6 kg block and the table is 11,76 N. A downwards force of 2 N is applied to the 2 kg block as indicated in the diagram below.



4.1 State Newton's Second Law of motion in words. (2)

4.2 Draw a free-body diagram showing ALL the forces acting on the 6 kg block. (4)

4.3 Calculate:

4.3.1 The magnitude of the acceleration of the 6 kg block. (5)

4.3.2 The magnitude of the tension (T) in the string connecting the two blocks. (2)

4.4 The rough surface is replaced by a smooth frictionless surface. How will this change affect the answer in QUESTION 4.3.1? Write only INCREASES, DECREASES or REMAINS THE SAME. (1)

[14]

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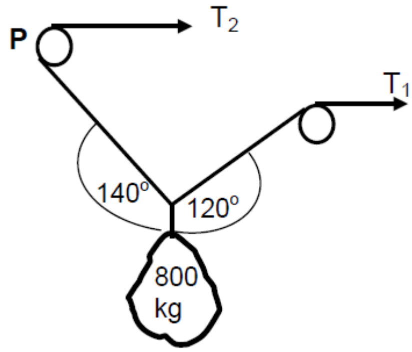
QUESTION 2 (Start on a new page.)

The diagram below shows a rope and pulley arrangement of a device being used to lift an 800 N object. Assume that the ropes are light and inextensible and also that the pulley is light and frictionless.



Determine the:

2.1 Magnitudes of the tensions $\mathbf{T_1}$ and $\mathbf{T_2}$ (7)

2.2 Magnitude and direction of the reaction force at pulley **P** (4)

[11]

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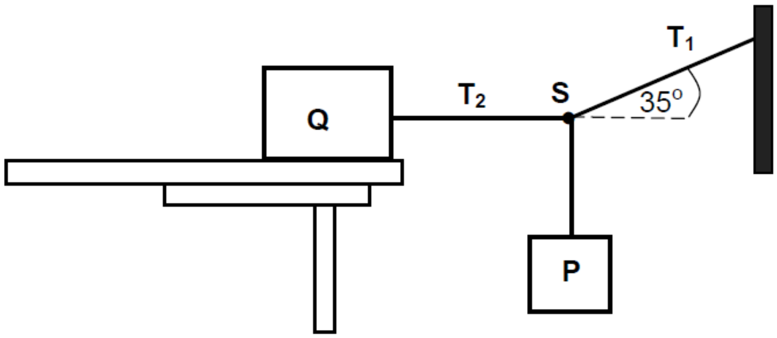
QUESTION 3 (Start on a new page.)

A block **Q** of mass 70 kg is at rest on a table. It is connected to block **P** by means of two light inextensible strings knotted at **S**. A third string is arranged in such a way that the string connecting block **Q** is **horizontal** as shown in the diagram below. The coefficient of static friction between block **Q** and the surface of the table is 0,25. The knot **S** is in equilibrium.



The tension in the string connecting block **Q** is T_2 and that for the string that pulls at 35° is T_1 as shown in the diagram.

3.1 Define the term *static frictional force* in words. (2)

3.2 Explain what is meant by *the knot S is in equilibrium.* (2)

3.3 Draw a labelled free-body diagram to show all the forces acting on:

3.3.1 The knot at **S** (3)

3.3.2 Block **Q** (4)

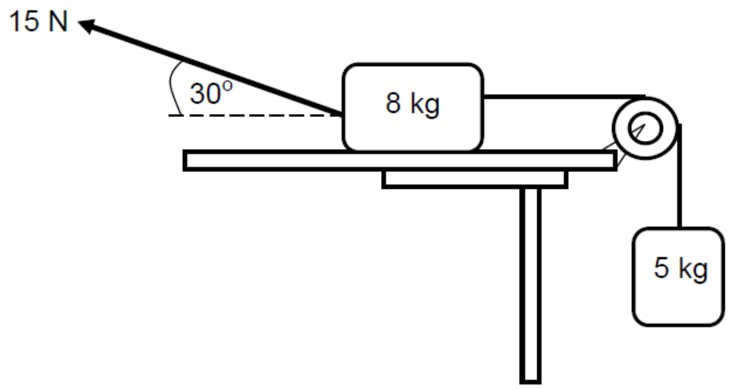
3.4 Calculate the maximum weight of block **P** for which block **Q** will just begin to slip. (7)

[18]

QUESTION 4 (Start on a new page.)

A block of mass 8 kg resting on a rough horizontal table is connected by a light inextensible string which passes over a light frictionless pulley to another block of mass 5 kg. The 5 kg block hangs vertically as shown in the diagram below.

A 15 N force is applied to the 8 kg block at an angle of 30° to the horizontal, causing the block to slide to the left.



The coefficient of kinetic friction between the 8 kg block and the surface of the table is 0,25. Ignore the effects of air friction.

4.1 Draw a free-body diagram showing ALL the forces acting on the 8 kg block. (5)

4.2 Write down Newton's second law of motion in words. (2)

Calculate the magnitude of the:

4.3 Normal force acting on the 8 kg block (3)

4.4 Tension in the string connecting the two blocks (6)
[16]

QUESTION 5 (Start on a new page.)

5.1 Write down Newton's law of universal gravitation in words. (2)

An object weighing 140 N on the surface of the earth is moved to a position which is $6,7 \times 10^6$ m above the surface of the earth.

5.2 Calculate the percentage by which its weight will change. (8)
[10]

J

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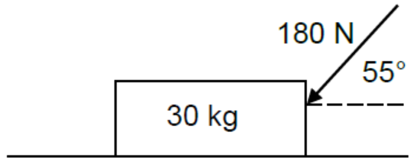
QUESTION 3: (Start on a new page.)

3.1 A force of 180 N is acting on a block at 55° to the horizontal as shown in the diagram. The block remains stationary.

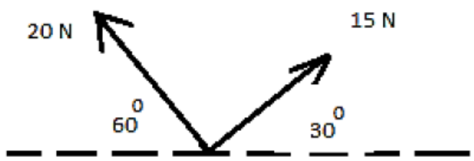


3.1.1 CONSTRUCT a vector diagram to determine the x- and y-components of the force. (Use a scale of 3 N : 1 mm) (7)

3.1.2 Use your answer in QUESTION 3.1.1 and calculate the normal force. (3)

3.2 Define a resultant vector. (2)

3.3 Two forces act on a point as indicated in the diagram below.



3.3.1 CALCULATE the magnitude of the resultant force. A vector diagram MUST accompany your calculations. (3)

3.3.2 CALCULATE the direction of the resultant force clockwise from the positive y-axis. (2)

3.4 What is meant by a CLOSED vector diagram and what conclusion can be made from such a diagram? (2)

[19]

QUESTION 4 (Start on a new page.)

A sled travelling at 6 $m.s^{-1}$ enters a stretch of snow as indicated in the diagram. The coefficient of kinetic friction is 6×10^{-2}.

4.1 Draw a free body diagram to show all forces that act on the sled. (NAME ALL FORCES.) (3)

4.2 Calculate:

4.2.1 The magnitude of the acceleration of the sled (4)

4.2.2 The distance travelled by the sled before stopping (3)

[10]

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QUESTION 5 (Start on a new page.)

Douglie and Bulie are pushing a car with a mass of 2 000 kg on a rough surface which has a frictional force of 500 N. Douglie applies a force of 400 N to the right and Bulie applies a force of 250 N in the same direction.

Frictional force = 500 N

5.1 Draw a free body diagram to show the **horizontal** forces acting on the car. (3)

5.2 Calculate the magnitude and direction of the acceleration of the car. (4)

5.3 If the road has a slight incline of 5°, calculate the component of the car's weight parallel to the incline. (2)

5.4 What will the motion of the car be on the incline, if Douglie and Bulie are applying the same force as before? Only write STATIONARY, ACCELERATE UP the incline, ACCELERATE DOWN the incline, MOVE AT A CONSTANT VELOCITY UP the incline OR MOVE WITH A CONSTANT VELOCITY DOWN the incline. (1)

5.5 The "Arrive alive campaign" always warns passengers and drivers to wear seatbelts when getting into vehicles to ensure their safety during accidents.

What is inertia? (1)

5.6 Explain, using relevant laws of physics, how a seatbelt works when a vehicle suddenly slows down in an accident. (2)

5.7 A book is resting on a table as shown below.

Write down Newton's third law of motion (2)

5.8 Identify all the Newton-third pairs that act ON THE DESK. (3)
[18]

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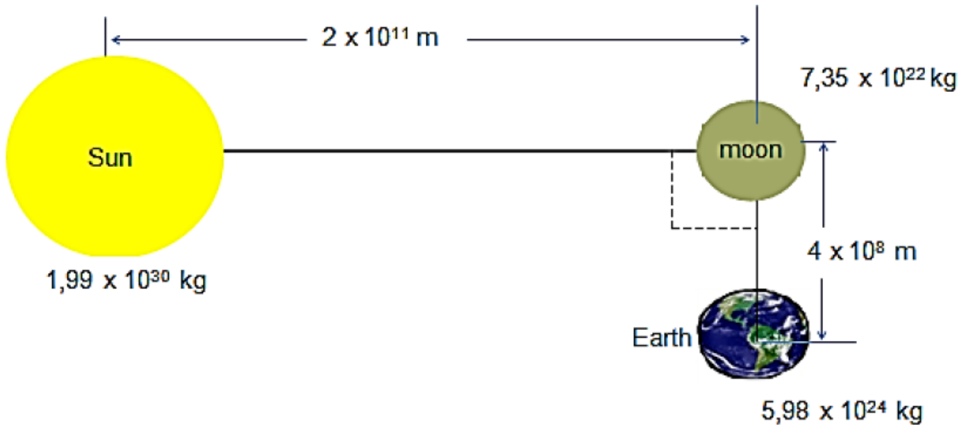
QUESTION 6 (Start on a new page.)

Consider the diagram below, which is not drawn to scale.



Calculate:

6.1 The magnitude of the gravitational force between the **earth and sun** at the position indicated in the diagram (5)

6.2 The acceleration due to gravity on the **moon** if the radius of the moon is $1,6 \times 10^6$ m (4)

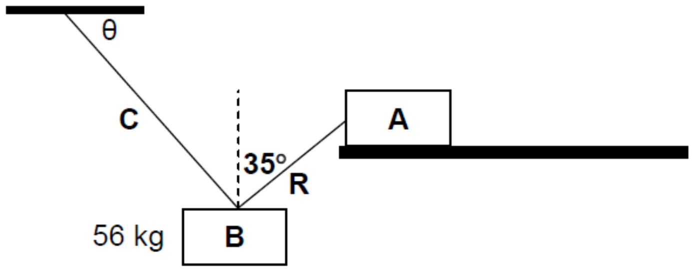
6.3 The weight of a 50 g object on **earth** (3)

[12]

K

QUESTION 2 (Start on a new page.)

Block **A**, which is at rest on a horizontal rough surface, is used as an anchor to hold block **B**, with a mass of 56 kg, in the air at a certain height above the ground. The two blocks are connected with rope **R**, which makes an angle of 35° with the vertical. Block **B** is suspended from the ceiling with cable **C**. Refer to the diagram below.



Block **A** experiences a frictional force of magnitude 200 N. The system is stationary.

2.1 Define the term *resultant vector*. (2)

2.2 What is the magnitude of the resultant force acting on block **B**? (1)

2.3 Draw a labelled free-body diagram indicating all the forces acting on block **B**. (3)

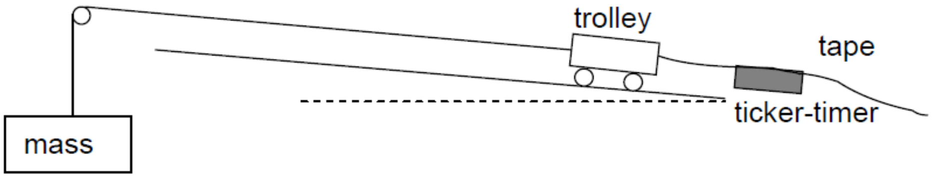
2.4 Determine the horizontal component of the force in rope **R**. (1)

2.5 Calculate the vertical component of the force in cable **C**. (4)

2.6 Calculate the angle θ between the cable and the ceiling. (2)
[13]

QUESTION 3 (Start on a new page.)

Learners investigate the relationship between net force and acceleration by pulling a trolley across a surface which is slightly inclined to compensate for friction. The trolley is connected to different masses by a string of negligible mass. The string passes over a frictionless pulley. Refer to the diagram below.



Ticker-tape attached to the trolley passes through the ticker-timer. The acceleration of the trolley is determined by analysing the ticker-tape. The results of the net force produced by the different masses and the acceleration of the trolley were recorded in the table below.

NET FORCE (N)	a ($m \cdot s^{-2}$)
0,3	0,36
0,6	0,73
0,9	1,09
1,2	1,45

3.1 Write down a hypothesis for this experiment. (2)

3.2.1 Identify the *independent variable*. (1)

3.2.2 Identify the *controlled variable*. (1)

3.3 Use the graph paper on the ANSWER SHEET and draw a graph of the acceleration versus net force. (4)

3.4 Calculate the gradient of the graph. (3)

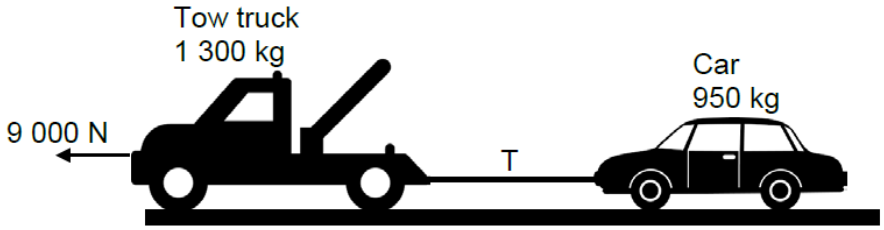
3.5 Use the gradient of the graph calculated in QUESTION 3.4 to determine the mass of the trolley. (2)

[13]

QUESTION 4 (Start on a new page.)

A tow truck pulls a car along a gravel road.

The force applied by the engine of the tow truck is 9 000 N. The mass of the tow truck is 1 300 kg and the mass of the car is 950 kg. The vehicles are connected to each other by an inelastic tow bar of negligible mass. See the diagram below.



The tow truck and car move at a CONSTANT VELOCITY.

4.1 Define the term *frictional force*. (2)

4.2 NAME AND STATE the law that explains why the force exerted by the tow truck on the car is the same as the force exerted by the car on the tow truck. (3)

4.3 Draw a labelled free-body diagram indicating all the forces acting on the tow truck. (5)

4.4 If the coefficient of kinetic friction between the tow-truck tyres and the road surface is 0,45, calculate the:

4.4.1 Magnitude of the tension in the tow bar (5)

4.4.2 Coefficient of kinetic friction between the CAR tyres and the road surface (5)

Suddenly the tow bar between the car and the tow truck disconnects and the car comes loose.

4.5 Using a relevant law of motion, explain why the car continues moving forward for a short distance. (3)

4.6 Calculate the acceleration of the car as it comes to a stop after a short distance. (3)

[26]