SA-STUDENT

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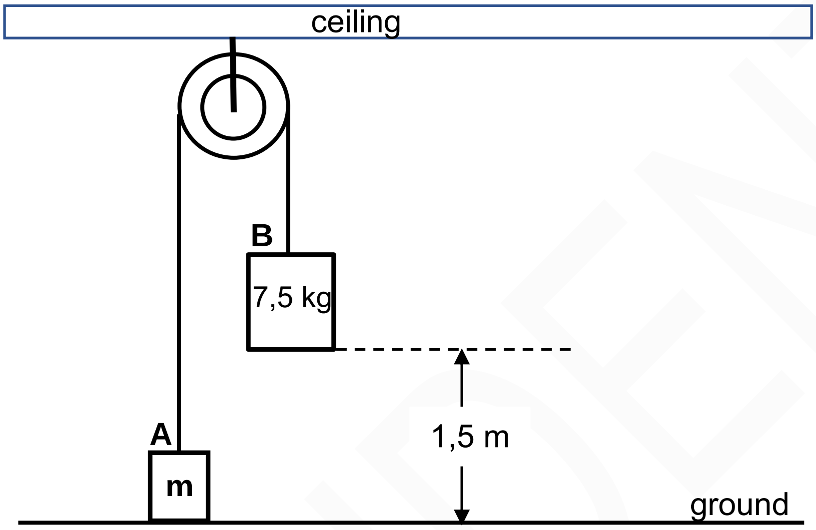
The best time to plant a tree is twenty years ago.

The second best time is now.

Chinese proverb

QUESTION 2 (Start on a new page.)

Block **A** of mass **m** is connected to block **B** of mass 7,5 kg by a light inextensible rope passing over a frictionless pulley. Block **B** is initially held at a height of 1,5 m above the ground, while block **A** is initially stationary on the ground, as shown in the diagram below.



When block **B** is released, it moves vertically downwards and strikes the ground with a velocity of 3,41 m·s^{-1}.

Ignore the effects of friction.

2.1 Show, by means of a calculation, that the magnitude of the acceleration of block **B** was 3,88 m·s^{-2} while the block was moving vertically downwards. (3)

2.2 Draw a labelled free-body diagram showing ALL the forces acting on block **B** immediately after it was released. (2)

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

2.4 Calculate the value of **m** by applying Newton's Second Law to EACH BLOCK while they are in motion. (5)

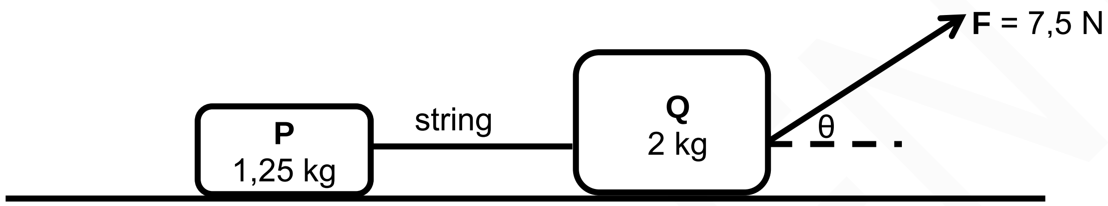
2.5 Calculate the maximum height above the ground reached by block **A**. (5)

[17]

QUESTION 2 (Start on a new page.)

Crate **P** of mass 1,25 kg is connected to another crate, **Q**, of mass 2 kg by a light inextensible string. The two crates are placed on a rough horizontal surface. A constant force **F** of magnitude 7,5 N, acting at angle θ to the horizontal, is applied on crate **Q**, as shown in the diagram below.

The crates accelerate at 0, $m \cdot s^{-2}$ to the right.



Crate **P** experiences a constant frictional force of 1,8 N and crate **Q** experiences a constant frictional force of 2,2 N.

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

2.2 Draw a labelled free-body diagram for crate **P**. (4)

2.3 Calculate the magnitude of:

2.3.1 The tension in the string (4)

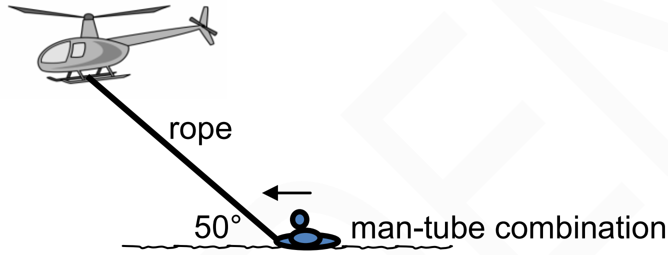
2.3.2 Angle θ (3)
[13]

QUESTION 2 (Start on a new page.)

A man faces difficulty while swimming in a dam. During the rescue operation, an inflated tube attached to a helicopter by a rope is dropped from the helicopter.

The man, of mass 70 kg, holds onto the inflated tube of mass 4 kg, while the helicopter is flying horizontally at a CONSTANT speed. An average frictional force of 300 N is exerted on the man-tube combination while they are dragged horizontally along the surface of the water by the helicopter. The rope makes an angle of 50° with the surface of the water, as shown in the diagram below.

Assume that the rope is inextensible and massless, and the water of the dam does not flow.



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

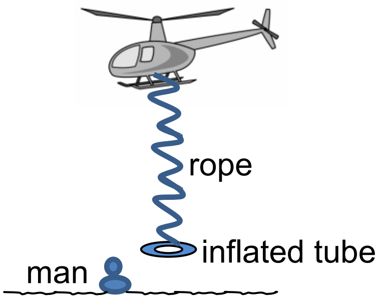
2.2 Draw a free-body diagram of the man-tube combination while they are being dragged. (4)

2.3 Calculate the tension in the rope. (4)

2.4 How will the answer to QUESTION 2.3 change if the helicopter ACCELERATES while dragging the man? The frictional force and the angle between the rope and the surface of the water remain the same.

Choose from INCREASES, DECREASES or NO CHANGE. Give a reason for the answer. (2)

In another rescue operation, the inflated tube of mass 4 kg is dropped from the stationary helicopter and it strikes the water at a speed of 16 $m \cdot s^{-1}$. The tube sinks vertically downwards into the water to a depth of 0,8 m and then rises to the surface. The rope hangs loosely.

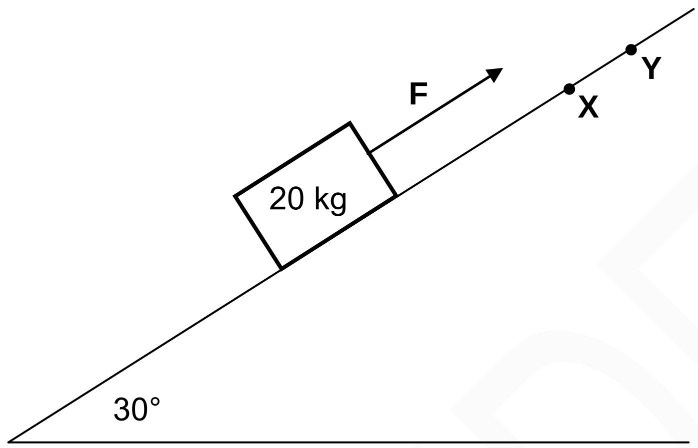


2.5 Calculate the magnitude of the average upward force exerted on the inflated tube while it is sinking. Assume that the average upward force is constant for the motion. (5)
[17]

QUESTION 2 (Start on a new page.)

A 20 kg block is placed on a rough surface inclined at 30° to the horizontal. A constant force **F**, acting parallel to the surface, is applied on the block so that the block moves up the incline at a CONSTANT VELOCITY of 2 $m \cdot s^{-1}$. Refer to the diagram below.

A constant kinetic frictional force of 18 N acts on the block.



2.1 State *Newton's First Law* in words. (2)

2.2 Draw a labelled free-body diagram for the block. (4)

2.3 Calculate the magnitude of force **F**. (4)

Force **F** is removed when the block reaches point **X** on the surface. The block continues to move up the surface and comes to rest momentarily at point **Y**.

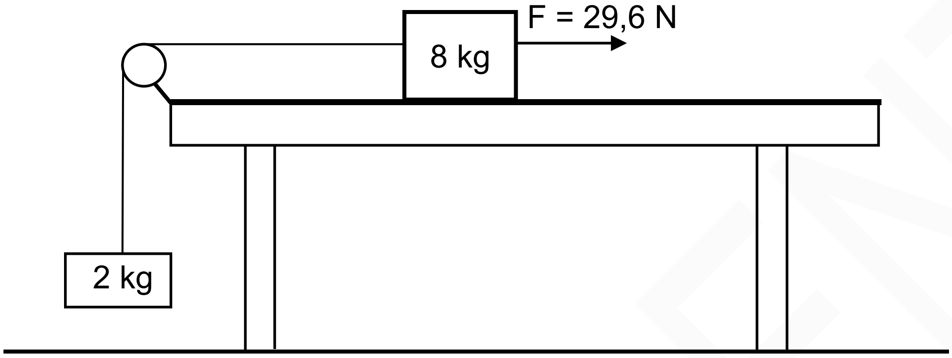
Assume that the kinetic frictional force acting on the block remains at 18 N as it moves from point **X** to point **Y**.

2.4 Write down the net force acting on the block as it moves from **X** to **Y**. (2)

2.5 Calculate the distance between points **X** and **Y**. (4)
[16]

QUESTION 2 (Start on a new page.)

An 8-kg block, on a rough horizontal surface, is connected to a 2-kg block by a light inextensible string passing over a frictionless pulley, as shown below. The 8-kg block moves at a **constant speed** when pulled by a 29,6 N horizontal force to the right. The frictional force acting on the 8-kg block is 10 N.



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

2.2 Draw a labelled free-body diagram for the 8-kg block. (5)

2.3 Calculate the tension in the string. (3)

The 29,6 N horizontal force is now increased to 50 N.

2.4 Apply Newton's Second Law to EACH block and calculate the:

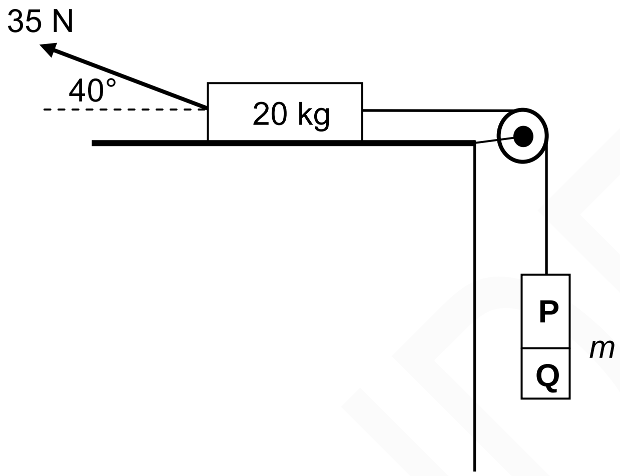
2.4.1 Magnitude of the acceleration of the 8-kg block (5)

2.4.2 Tension in the string (2)
[17]

QUESTION 2 (Start on a new page.)

A 20 kg block, resting on a rough horizontal surface, is connected to blocks **P** and **Q** by a light inextensible string moving over a frictionless pulley. Blocks **P** and **Q** are glued together and have a combined mass of *m*.

A force of 35 N is now applied to the 20 kg block at an angle of 40° with the horizontal, as shown below.



The 20 kg block experiences a frictional force of magnitude 5 N as it moves to the RIGHT at a CONSTANT SPEED.

2.1 Define the term *normal force*. (2)

2.2 Draw a labelled free-body diagram of the 20 kg block. (5)

2.3 Calculate the combined mass *m* of the two blocks. (5)

2.4 At a certain stage of the motion, block **Q** breaks off and falls down.

How will EACH of the following be affected when this happens?

2.4.1 The tension in the string
Choose from INCREASES, DECREASES or REMAINS THE SAME. (1)

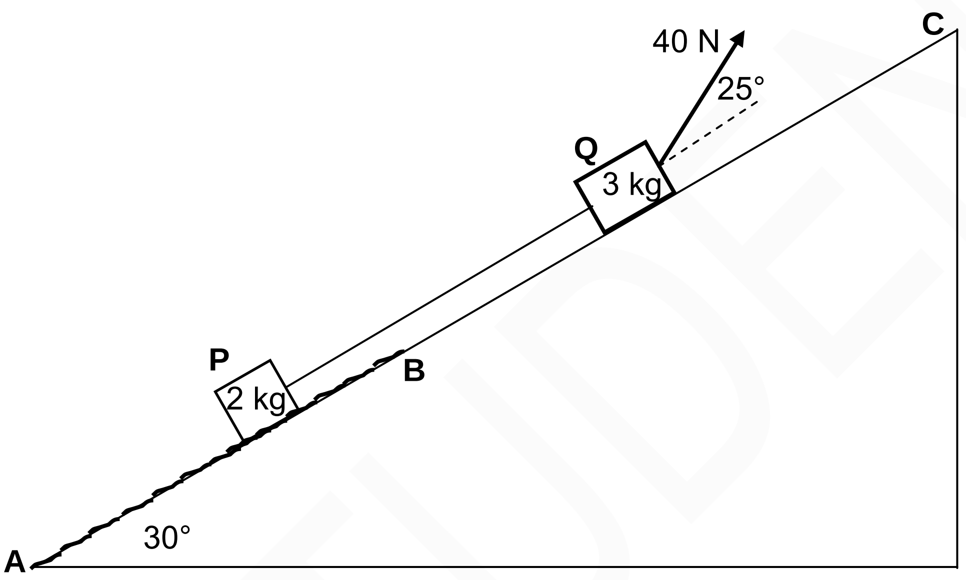
2.4.2 The velocity of the 20 kg block
Explain the answer. (3)
[16]

QUESTION 2 (Start on a new page.)

Block **P**, of mass 2 kg, is connected to block **Q**, of mass 3 kg, by a light inextensible string. Both blocks are on a plane inclined at an angle of 30° to the horizontal.

Block **Q** is pulled by a constant force of 40 N at an angle of 25° to the incline.

Block **P** moves on a rough section, **AB**, of the incline, while block **Q** moves on a frictionless section, **BC**, of the incline. See diagram below.



An average constant frictional force of 2,5 N acts on block **P** as it moves from **A** to **B** up the incline.

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

2.2 Draw a labelled free-body diagram for block **P**. (4)

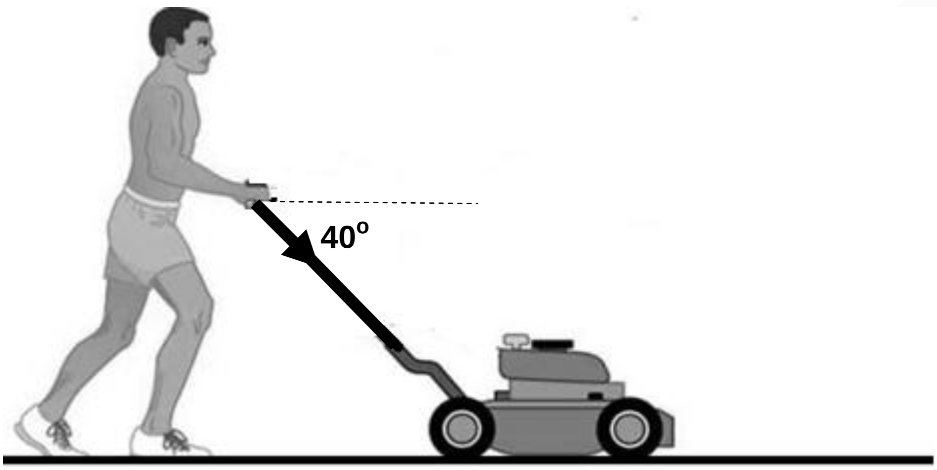
2.3 Calculate the magnitude of the acceleration of block **P** while block **P** is moving on section **AB**. (8)

2.4 If block **P** has now passed point **B**, how will its acceleration compare to that calculated in QUESTION 2.3? Choose from GREATER THAN, SMALLER THAN or EQUAL TO.

Give a reason for the answer. (2)
[16]

QUESTION 2 (Start on a new page.)

2.1 A person pushes a lawn mower of mass 15 kg at a **constant speed** in a straight line over a flat grass surface with a force of 90 N. The force is directed along the handle of the lawn mower. The handle has been set at an angle of 40° to the horizontal. Refer to the diagram below.



2.1.1 Draw a labelled free-body diagram for the lawn mower. (4)

2.1.2 Why is it CORRECT to say that the moving lawn mower is in equilibrium? (1)

2.1.3 Calculate the magnitude of the frictional force acting between the lawn mower and the grass (3)

The lawn mower is now brought to a stop.

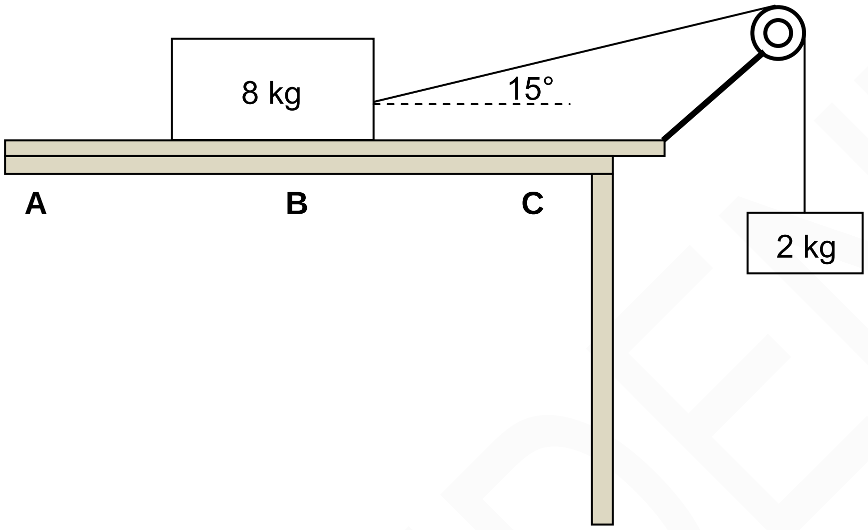
2.1.4 Calculate the magnitude of the constant force that must be applied through the handle in order to accelerate the lawn mower *from rest* to 2 $m \cdot s^{-1}$ in a time of 3 s. Assume that the frictional force between the lawn mower and grass remains the same as in QUESTION 2.1.3. (6)

2.2 Planet **Y** has a radius of 6×10^5 m. A 10 kg mass weighs 20 N on the surface of planet **Y**.

Calculate the mass of planet **Y**. (4)
[18]

QUESTION 2 (Start on a new page.)

A block, of mass 8 kg, is placed on a rough horizontal surface. The 8 kg block, which is connected to a 2 kg block by means of a light inextensible string passing over a light frictionless pulley, starts sliding from point **A**, as shown below.



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

2.2 Draw a labelled free-body diagram for the 8 kg block. (4)

2.3 When the 8 kg block reaches point **B**, the angle between the string and the horizontal is 15° and the acceleration of the system is 1,32 $m \cdot s^{-2}$.

2.3.1 Give a reason why the system is NOT in equilibrium. (1)

2.3.2 Use the 2 kg mass to calculate the tension in the string. (3)

2.3.3 Calculate the kinetic frictional force between the 8 kg block and the horizontal surface. (4)

2.4 As the 8 kg block moves from **B** to **C**, the kinetic frictional force between the 8 kg block and the horizontal surface is not constant.

Give a reason for this statement. (1)

The horizontal surface on which the 8 kg block is moving, is replaced by another horizontal surface made from a different material.

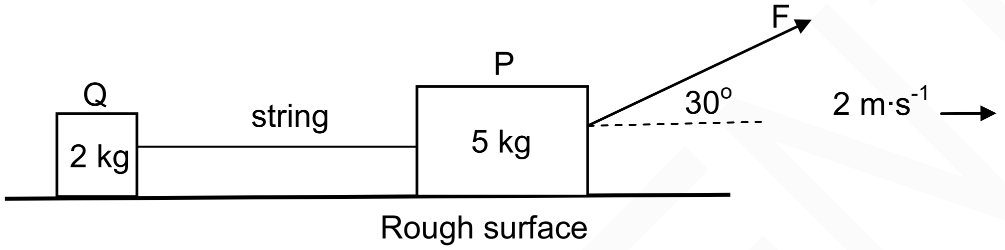
2.5 Will the kinetic frictional force, calculated in QUESTION 2.3.3 above, change? Choose from: YES or NO. Give a reason for the answer. (2)

[17]

QUESTION 2 (Start on a new page.)

Two boxes, **P** and **Q**, resting on a rough horizontal surface, are connected by a light inextensible string. The boxes have masses 5 kg and 2 kg respectively. A constant force **F**, acting at an angle of 30° to the horizontal, is applied to the 5 kg box, as shown below.

The two boxes now move to the right at a **constant speed** of 2 m·s^{-1}.



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

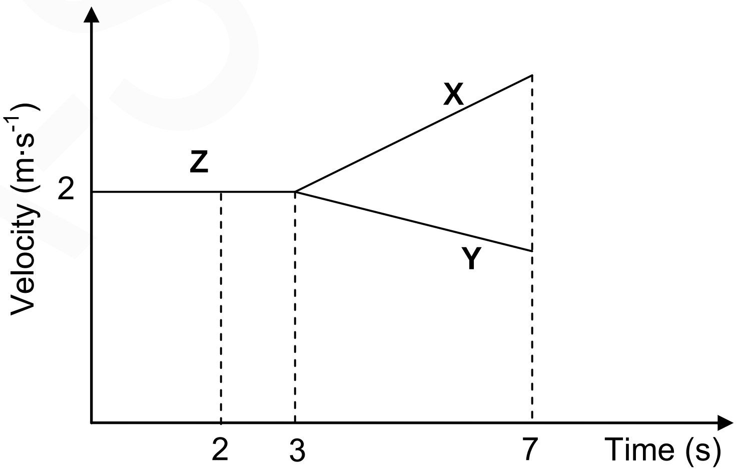
2.2 Draw a labelled free-body diagram for box **Q**. (4)

Box **P** experiences a constant frictional force of 5 N and box **Q** a constant frictional force of 3 N.

2.3 Calculate the magnitude of force **F**. (6)

The string connecting **P** and **Q** suddenly breaks after 3 s while force **F** is still being applied.

Learners draw the velocity-time graph for the motion of **P** and **Q** before and after the string breaks, as shown below.

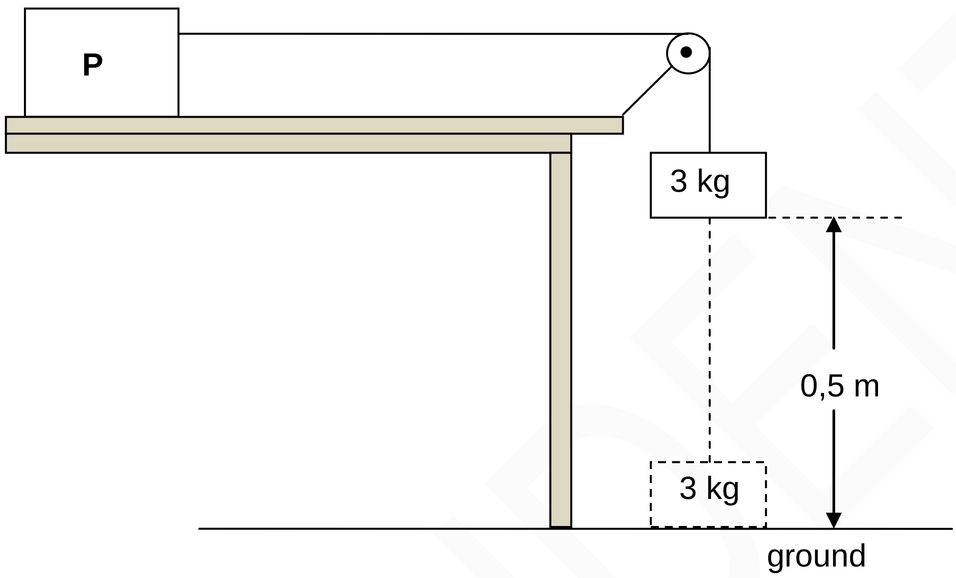


2.4 Write down the time at which the string breaks. (1)

2.5 Which portion (**X**, **Y** or **Z**) of the graph represents the motion of box **Q**, after the string breaks? Use the information in the graph to fully support the answer. (4)
[17]

QUESTION 2 (Start on a new page.)

Block **P**, of unknown mass, is placed on a rough horizontal surface. It is connected to a second block of mass 3 kg, by a light inextensible string passing over a light, frictionless pulley, as shown below.



Initially the system of masses is held stationary with the 3 kg block, 0,5 m above the ground. When the system is released the 3 kg block moves vertically downwards and strikes the ground after 3 s. Ignore the effects of air resistance.

2.1 Define the term *acceleration* in words. (2)

Calculate the magnitude of the:

2.2 Acceleration of the 3 kg block using equations of motion (3)

2.3 Tension in the string (3)

The magnitude of the kinetic frictional force experienced by block **P** is 27 N.

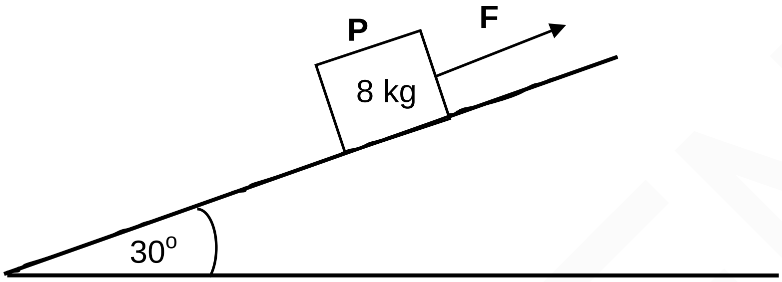
2.4 Draw a labelled free-body diagram for block **P**. (4)

2.5 Calculate the mass of block **P**. (3)
[15]

QUESTION 2 (Start on a new page.)

2.1 An 8 kg block, **P**, is being pulled by constant force **F** up a rough inclined plane at an angle of 30^o to the horizontal, at CONSTANT SPEED.

Force **F** is parallel to the inclined plane, as shown in the diagram below.



2.1.1 State Newton's First Law in words. (2)

2.1.2 Draw a labelled free-body diagram for block **P**. (4)

The kinetic frictional force between the block and the surface of the inclined plane is 20,37 N.

2.1.3 Calculate the magnitude of force **F**. (5)

Force **F** is now removed and the block ACCELERATES down the plane. The kinetic frictional force remains 20,37 N.

2.1.4 Calculate the magnitude of the acceleration of the block. (4)

2.2 A 200 kg rock lies on the surface of a planet. The acceleration due to gravity on the surface of the planet is 6,0 m·s^{-2}.

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

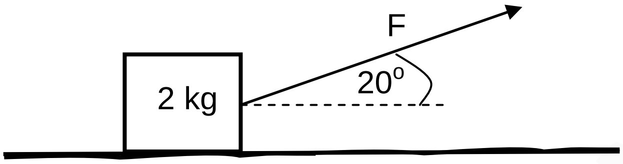
2.2.2 Calculate the mass of the planet if its radius is 700 km. (4)

[21]

QUESTION 2 (Start on a new page.)

2.1 A crate of mass 2 kg is being pulled to the right across a *rough* horizontal surface by a constant force F.

The force F is applied at an angle of 20° to the horizontal, as shown in the diagram below.



2.1.1 Draw a labelled free-body diagram showing ALL the forces acting on the crate. (4)

A constant frictional force of 3 N acts between the surface and the crate. The coefficient of kinetic friction between the crate and the surface is 0,2.

Calculate the magnitude of the:

2.1.2 Normal force acting on the crate (3)

2.1.3 Force F (4)

2.1.4 Acceleration of the crate (3)

2.2 A massive rock from outer space is moving towards the Earth.

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

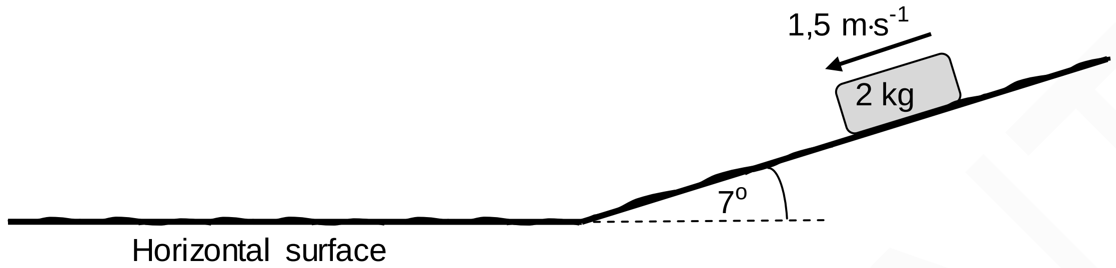
2.2.2 How does the magnitude of the gravitational force exerted by the Earth on the rock change as the distance between the rock and the Earth becomes smaller?

Choose from INCREASES, DECREASES or REMAINS THE SAME.

Give a reason for the answer. (2)
[18]

QUESTION 2 (Start on a new page.)

In the diagram below, a small object of mass 2 kg is sliding *at a constant velocity* of 1,5 m·s^{-1} down a rough plane inclined at 7^o to the horizontal surface.



At the bottom of the plane, the object continues sliding onto the rough horizontal surface *and eventually comes to a stop*.

The coefficient of kinetic friction between the object and the surface is *the same for both the inclined surface and the horizontal surface.*

2.1 Write down the magnitude of the net force acting on the object. (1)

2.2 Draw a labelled free-body diagram for the object while it is on the inclined plane. (3)

2.3 Calculate the:

2.3.1 Magnitude of the frictional force acting on the object while it is sliding down the inclined plane (3)

2.3.2 Coefficient of kinetic friction between the object and the surfaces (3)

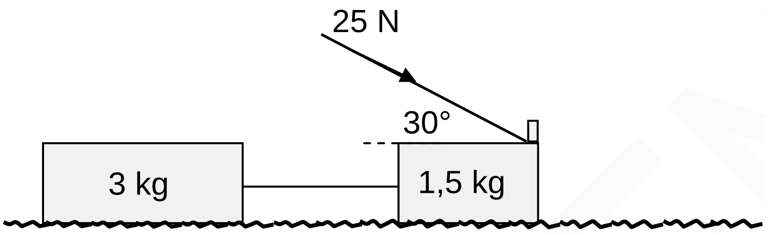
2.3.3 Distance the object travels on the horizontal surface before it comes to a stop (5)

[15]

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:

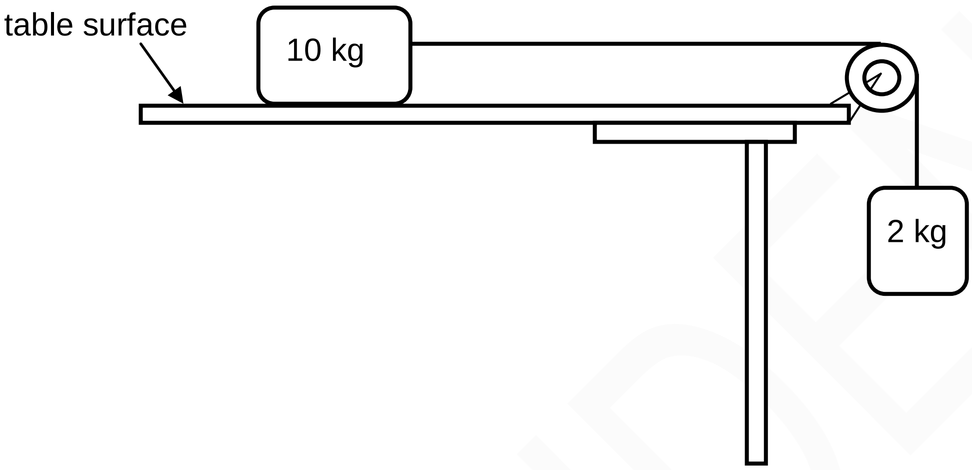
2.4.1 Kinetic frictional force acting on the 1,5 kg block (3)

2.4.2 Tension in the cord connecting the two blocks (5)
[18]

QUESTION 2 (Start on a new page.)

The diagram below shows a 10 kg block lying on a flat, rough, horizontal surface of a table. The block is connected by a light, inextensible string to a 2 kg block hanging over the side of the table. The string runs over a light, frictionless pulley.

The blocks are **stationary**.



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

2.2 Write down the magnitude of the NET force acting on the 10 kg block. (1)

When a 15 N force is applied vertically downwards on the 2 kg block, the 10 kg block accelerates to the right at 1,2 $m \cdot s^{-2}$.

2.3 Draw a free-body diagram for the 2 kg block when the 15 N force is applied to it. (3)

2.4 Calculate the coefficient of kinetic friction between the 10 kg block and the surface of the table. (7)

2.5 How does the value, calculated in QUESTION 2.4, compare with the value of the coefficient of STATIC friction for the 10 kg block and the table? Write down only LARGER THAN, SMALLER THAN or EQUAL TO. (1)

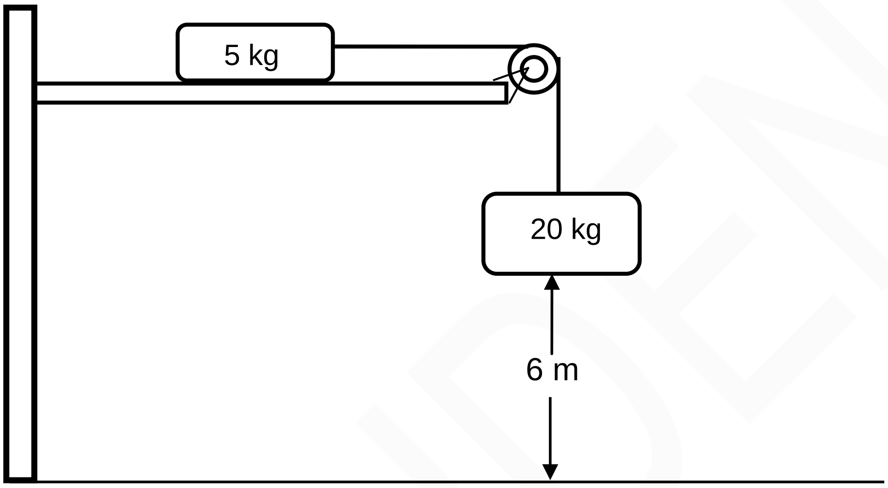
2.6 If the 10 kg block had a larger surface area in contact with the surface of the table, how would this affect the coefficient of kinetic friction calculated in QUESTION 2.4? Assume that the rest of the system remains unchanged. Write down only INCREASES, DECREASES or REMAINS THE SAME. Give a reason for the answer. (2)

[16]

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.



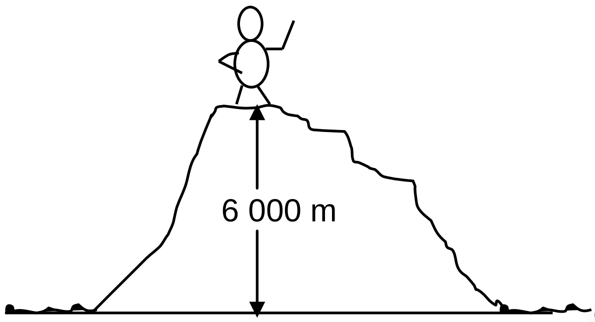
When the *stationary* 5 kg mass is released, the two masses begin to move. The coefficient of kinetic friction, μ_k, between the 5 kg mass and the horizontal surface is 0,4. Ignore the effects of air friction.

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)

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]

QUESTION 3 (Start on a new page.)

A man throws ball **A** downwards with a speed of 2 $m \cdot s^{-1}$ from the edge of a window, 45 m above a dam of water. One second later he throws a second ball, ball **B**, downwards and observes that both balls strike the surface of the water in the dam at the same time. Ignore air friction.

3.1 Calculate the:

3.1.1 Speed with which ball **A** hits the surface of the water (3)

3.1.2 Time it takes for ball **B** to hit the surface of the water (3)

3.1.3 Initial velocity of ball **B** (5)

3.2 On the same set of axes, sketch a velocity versus time graph for the motion of balls **A** and **B**. Clearly indicate the following on your graph:

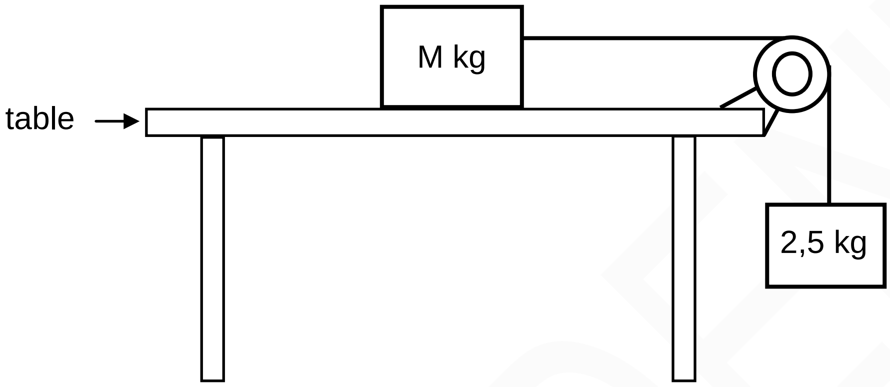
- Initial velocities of both balls **A** and **B**
- The time of release of ball **B**
- The time taken by both balls to hit the surface of the water (5)

[16]

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)

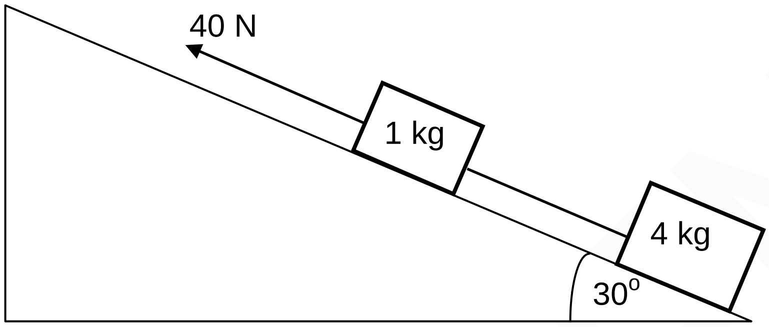
2.2 A small hypothetical planet X has a mass of $6,5 \times 10^{20}$ kg and a radius of 550 km.

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

[19]

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)

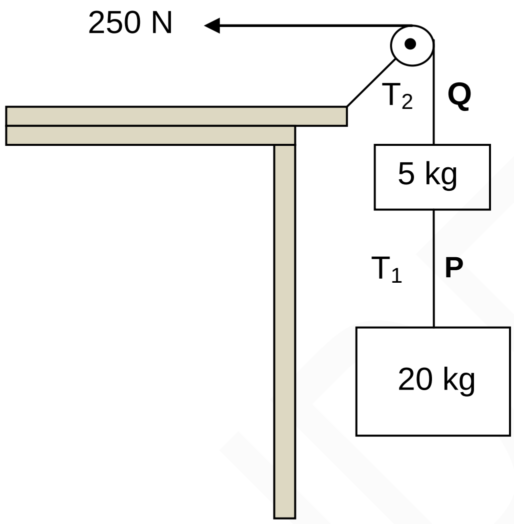
2.3 Calculate the magnitude of the:

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]

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)

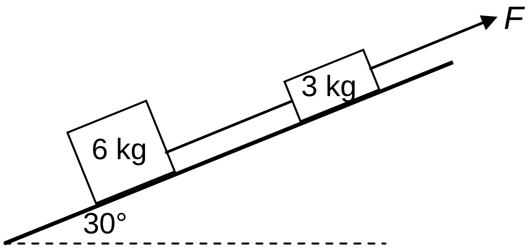
2.3 Calculate the magnitude of the tension T_1 in string **P**. (6)

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]

QUESTION 2 (Start on a new page.)

A light inelastic string connects two objects of mass 6 kg and 3 kg respectively. They are pulled up an inclined plane that makes an angle of 30° with the horizontal, with a force of magnitude *F*. Ignore the mass of the string.



The coefficient of kinetic friction for the 3 kg object and the 6 kg object is 0,1 and 0,2 respectively.

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

2.2 How will the coefficient of kinetic friction be affected if the angle between the incline and the horizontal increases? Write down only INCREASES, DECREASES or REMAINS THE SAME. (1)

2.3 Draw a labelled free-body diagram indicating all the forces acting on the 6 kg object as it moves up the inclined plane. (4)

2.4 Calculate the:

2.4.1 Tension in the string if the system accelerates up the inclined plane at 4 $m \cdot s^{-2}$ (5)

2.4.2 Magnitude of *F* if the system moves up the inclined plane at CONSTANT VELOCITY (6)

2.5 How would the tension in the string, calculated in QUESTION 2.4.1, be affected if the system accelerates up a FRICTIONLESS inclined plane at 4 $m \cdot s^{-2}$? Write down only INCREASES, DECREASES OR REMAINS THE SAME. (1)

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