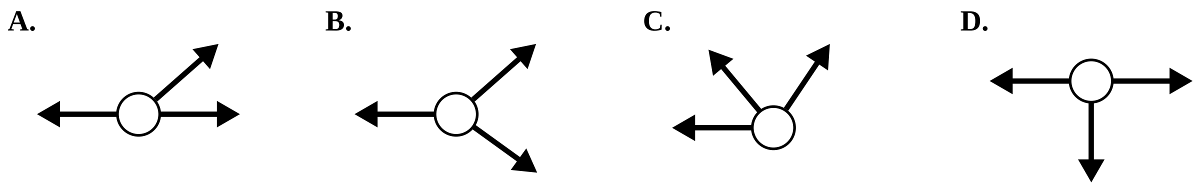
Question 3

A metal ring is to be held stationary by three forces that are all pulling on the ring. All the forces are greater than zero, but their magnitudes are not given. Possible directions of the forces on the ring are shown in the arrangements in Figure 5. Only one of these arrangements can hold the ring stationary.



Not to scale

Figure 5

Identify which one of the arrangements (**A.–D.**) shown in Figure 5 could hold the metal ring stationary and explain the reasons for your answer.

2 marks

Question 4

Two metal spheres hang from the ceiling as shown in Figure 6. Cable A runs between the ceiling and the upper sphere of mass 2.0 kg. Cable B runs between the 2.0 kg sphere and the 1.0 kg sphere. Assume that the cables have no mass.

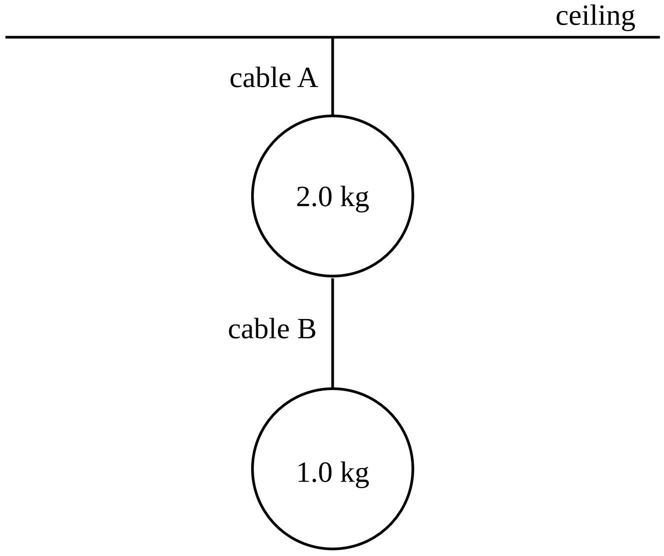


Figure 6

a. State the force (magnitude and direction) that cable A applies to the 2.0 kg sphere.

Force magnitude	N
Force direction	

2 marks

b. Newton's third law is sometimes stated as 'To every action there is an equal and opposite reaction'. If the weight (the gravitational force by Earth) of the 2.0 kg sphere is taken as the 'action' force, identify the corresponding 'reaction' force and give its direction.

2 marks

Question 5

A truck is dragging two logs along level ground in a straight line. The mass of each log is 600 kg and each log experiences a constant retarding friction force of 400 N with the ground.

The connections between the truck and the logs are made with ropes that have a breaking force of 2400 N.

T_1 and T_2 are the tensions in the ropes as shown in Figure 7. The truck and the logs are moving towards the **left** in Figure 7.

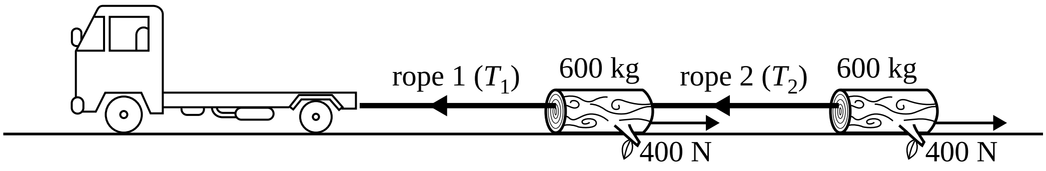


Figure 7

a. Calculate the magnitude of T_1 when the truck is driving at a constant speed.

N

1 mark

b. The truck then accelerates at a rate of 0.50 m s^{-2}. Calculate the magnitude of T_2.

N

2 marks

c. At a point in time, the driver observes that the speed of the truck is 4.0 m s^{-1}. The truck then keeps accelerating at 0.50 m s^{-2} for another 20 m. Calculate the speed of the truck at the end of the 20 m.

m s^{-1}

2 marks

SECTION A – Core studies

Area of study – Motion in one and two dimensions

Question 1 (5 marks)

Students set up an inclined plane surface, as shown in Figure 1a. It is angled at 10° to the horizontal. They place a frictionless trolley of mass 0.50 kg at the top of the incline, so that the distance from the front of the trolley to the stopper at the bottom is 3.5 m.

They release the trolley from rest and findthatittakes2.0storeachthestopperatthebottom.

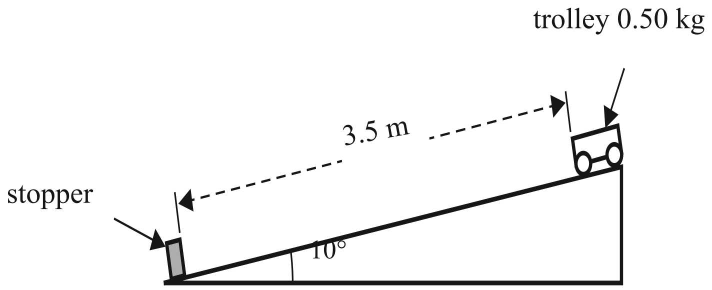


Figure 1a

a. Calculate the acceleration of the trolley. 2 marks

m s^{-2}

b. The students replace the frictionless trolley with a block of wood of the same mass. They release the block of wood at a distance of 3.5 m from the stopper, the same as they did with the trolley. When the block is sliding down the incline, there is a constant frictional force between it and the surface. They find that it takes 6.0 s to reach the stopper at the bottom.

Calculate the magnitude of the frictional force of the plane surface acting on the block. 3 marks

Question 2 (4 marks)

Students set up an experiment as shown in Figure 2.

M_1, of mass 4.0 kg, is connected by a light string (assume it has no mass) to a hanging mass, M_2, of 1.0 kg. The system is initially at rest. Ignore mass of string and friction.

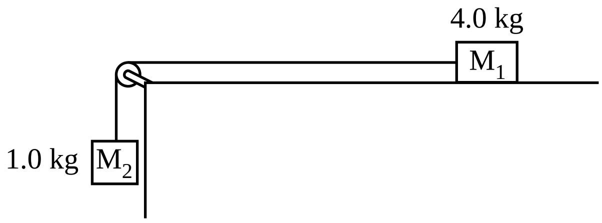


Figure 2

The masses are released from rest.

a. Calculate the acceleration of M_1. 2 marks

m s^{-2}

b. Calculate the magnitude of the tension in the string as the masses accelerate. 2 marks

N

SECTION A – Core studies

Instructions for Section A

Answer **all** questions in this section in the spaces provided. Write using blue or black pen.
Where an answer box has a unit printed in it, give your answer in that unit.
You should take the value of g to be 10 m s^{-2}.
Where answer boxes are provided, write your final answer in the box.
In questions worth more than 1 mark, appropriate working should be shown.
Unless otherwise indicated, the diagrams in this book are **not** drawn to scale.

Area of study – Motion in one and two dimensions

Question 1 (11 marks)

a. A train consists of an engine of mass 20 tonnes (20 000 kg) towing one wagon of mass 10 tonnes (10 000 kg), as shown in Figure 1.

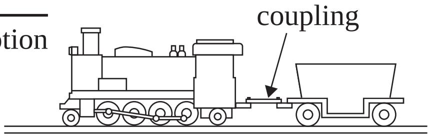


Figure 1

The train accelerates from rest with a constant acceleration of 0.10 m s^{-2}.

Calculate the speed of the train after it has moved 20 m. Show your working. 2 marks

m s^{-1}

b. The wagon has a frictional resistance of 2000 N.

Calculate the tension in the coupling between the engine and the wagon. 2 marks

N

Question 3 (4 marks)

To determine the spring constant, *k*, of a spring, students attach 50 g masses to it consecutively and measure the extension, Δx. This is shown in Figure 4a.

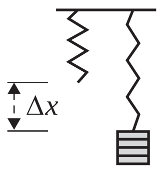


Figure 4a

The students' results are shown in the table below.

Number of masses	Extension from unstretched length, Δx
0	0 cm
1	25 cm
2	50 cm
3	75 cm

a. Calculate the value of the spring constant, *k*. 2 marks

N m^{-1}

SECTION A – Core studies

Instructions for Section A

Answer **all** questions in this section in the spaces provided. Write using blue or black pen.
Where an answer box has a unit printed in it, give your answer in that unit.
You should take the value of g to be 10 m s^{-2}.
Where answer boxes are provided, write your final answer in the box.
In questions worth more than 1 mark, appropriate working should be shown.
Unless otherwise indicated, the diagrams in this book are **not** drawn to scale.

Area of study – Motion in one and two dimensions

Question 1 (8 marks)

A tugboat is towing two barges (unpowered boats) connected by cables, as shown in Figure 1.
The tugboat has a mass of 100 tonnes and each barge has a mass of 200 tonnes.

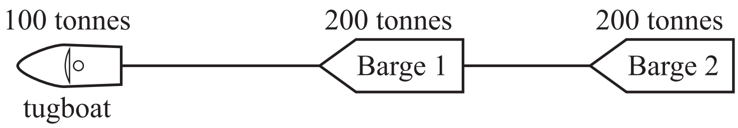


Figure 1

The tugboat starts from rest and accelerates at 0.50 m s^{-2}.

a. Calculate the distance that the tugboat and its barges travel in the first 10 s. 2 marks

m

b. Calculate the force applied by the tugboat's engine. Ignore any friction. 2 marks

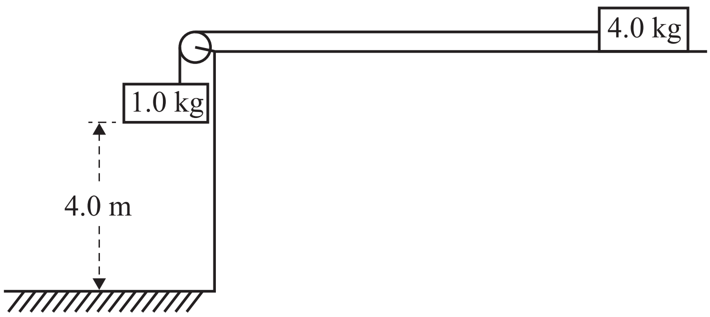
N

c. Calculate the tension in the cable connecting the tugboat and Barge 1. 2 marks

N

Use the following information to answer Questions 8 and 9.

A 1.0 kg mass attached to a string is hanging 4.0 m from the ground. Assume that the string has no mass. The string is connected to a 4.0 kg mass on a horizontal frictionless table, as shown below. The masses are released from rest and an acceleration of 1.96 m s^{-2} is observed.



Question 8

The tension in the string is closest to

A. 19.6 N

B. 15.6 N

C. 9.8 N

D. 7.8 N

Question 9

Which one of the following best gives the speed of the 4.0 kg mass when the 1.0 kg mass strikes the ground after falling 4.0 m?

A. 2.0 m s^{-1}

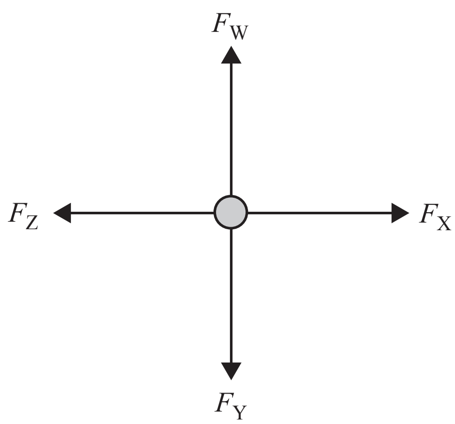
B. 4.0 m s^{-1}

C. 8.0 m s^{-1}

D. 16 m s^{-1}

Question 5

Four students are pulling on ropes in a four-person tug of war. The relative sizes of the forces acting on the various ropes are $F_W = 200$ N, $F_X = 240$ N, $F_Y = 180$ N and $F_Z = 210$ N. The situation is shown in the diagram below.



Which one of the following **best** gives the magnitude of the resultant force acting at the centre of the tug-of-war ropes?

A. 28.3 N

B. 30.0 N

C. 36.1 N

D. 50.0 N

Question 8 (4 marks)

Two blocks, A of mass 4.0 kg and B of mass 1.0 kg, are being pushed to the right on a smooth, frictionless surface by a 40 N force, as shown in Figure 10.

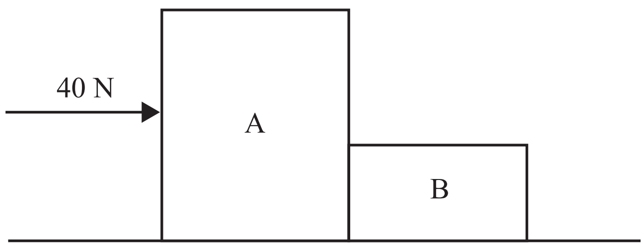


Figure 10

a. Calculate the magnitude of the force on block B by block A ($F_{\text{on B by A}}$). Show your working. 2 marks

N

b. State the magnitude and the direction of the force on block A by block B ($F_{\text{on A by B}}$). 2 marks

N

Question 9 (2 marks)

Figure 10 shows two masses. Mass A has a mass of 10 kg. It rests on top of Mass B, which has a mass of 20 kg.

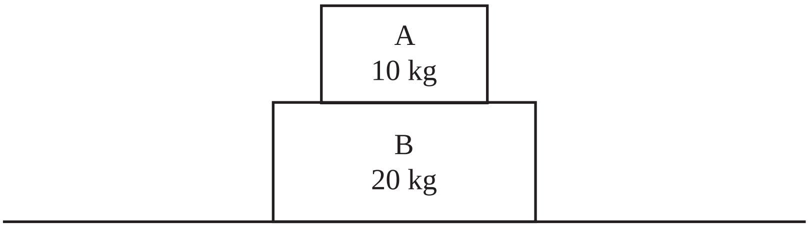


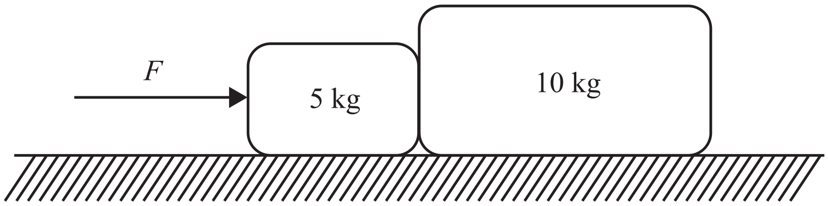
Figure 10

Calculate the magnitude and direction of the force on Mass A by Mass B. Take $g = 9.8\ \text{N kg}^{-1}$.

N	

Use the following information to answer Questions 9 and 10.

Two blocks of mass 5 kg and 10 kg are placed in contact on a frictionless horizontal surface, as shown in the diagram below. A constant horizontal force, *F*, is applied to the 5 kg block.



Question 9

Which one of the following statements is correct?

A. The net force on each block is the same.

B. The acceleration experienced by the 5 kg block is twice the acceleration experienced by the 10 kg block.

C. The magnitude of the net force on the 5 kg block is half the magnitude of the net force on the 10 kg block.

D. The magnitude of the net force on the 5 kg block is twice the magnitude of the net force on the 10 kg block.

Question 10

If the force *F* has a magnitude of 250 N, what is the work done by the force in moving the blocks in a straight line for a distance of 20 m?

A. 5 kJ

B. 25 kJ

C. 50 kJ

D. 500 kJ

Question 8 (8 marks)

A car is driving up a uniform slope with a trailer attached, as shown in Figure 11. The slope is angled at 15° to the horizontal. The trailer has a mass of 200 kg and the car has a mass of 750 kg. Ignore all retarding friction forces down the slope.

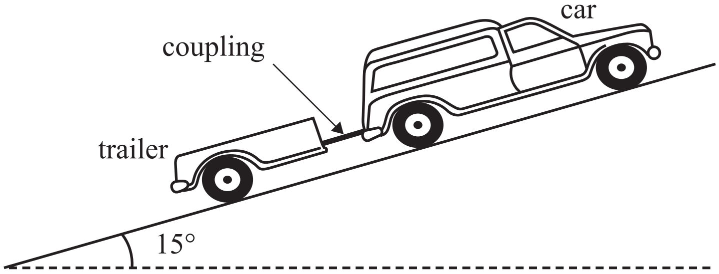


Figure 11

a. On Figure 12 below, draw labelled arrows to indicate the direction of the forces acting on the trailer. The labels should also indicate the kind of force that each arrow represents. 3 marks

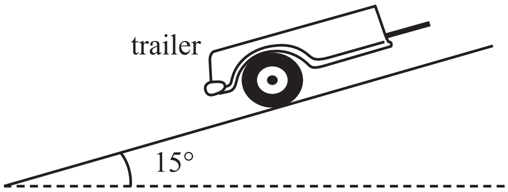


Figure 12

b. The car and trailer are travelling at a constant speed of 8 m s^{-1} up the slope.

Calculate the magnitude of the force that the car exerts on the trailer. Show your working. 2 marks

N

Question 4 (2 marks)

Liesel, a student of yoga, sits on the floor in the lotus pose, as shown in Figure 4. The action force, F_g, on Liesel due to gravity is 500 N down.

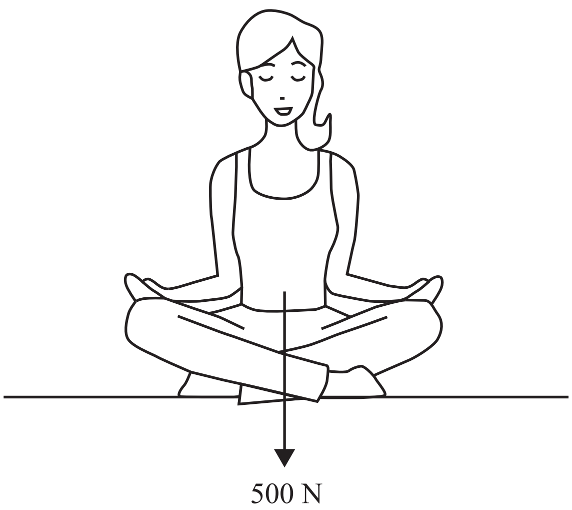
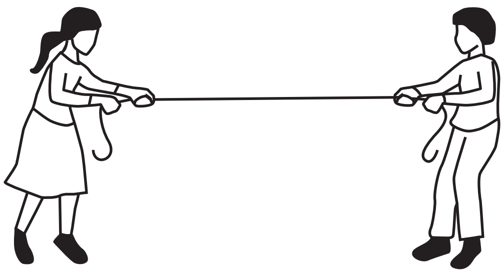


Figure 4

Identify and explain what the reaction force is to the action force, F_g, shown in Figure 4.

Question 9

Two students pull on opposite ends of a rope, as shown in the diagram below. Each student pulls with a force of 400 N.



Which one of the following is closest to the magnitude of the force of the rope on each student?

A. 0 N

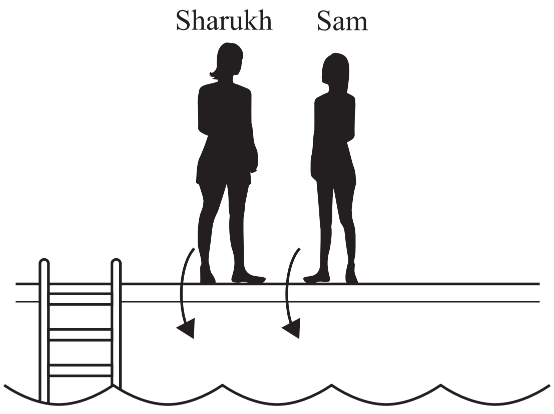
B. 400 N

C. 600 N

D. 800 N

Question 8

At a swimming pool, Sharukh and Sam, shown below, step off the low diving board at the same time. Over the small distance they fall, air resistance may be ignored. Sharukh and Sam have masses of 80 kg and 60 kg respectively.



Which one of the following best explains what happens to Sharukh and Sam as they drop straight down into the water?

A. Sharukh reaches the surface first because she has a larger mass.

B. The net force on Sharukh is larger than that on Sam, so Sharukh reaches the surface first.

C. They both reach the surface together because they both experience the same downward force.

D. They both reach the surface together because they both experience the same downward acceleration.

SECTION B

Instructions for Section B

Answer **all** questions in the spaces provided.

Where an answer box is provided, write your final answer in the box.

If an answer box has a unit printed in it, give your answer in that unit.

In questions where more than one mark is available, appropriate working **must** be shown.

Unless otherwise indicated, the diagrams in this book are **not** drawn to scale.

Take the value of g to be 9.8 m s^{-2}.

Question 1 (7 marks)

Some physics students are conducting an experiment investigating both electrostatic and gravitational forces. They suspend two equally charged balls, each of mass 4.0 g, from light, non-conducting strings suspended from a low ceiling.

The charged balls repel each other with the strings at an angle of 60°, as shown in Figure 1.

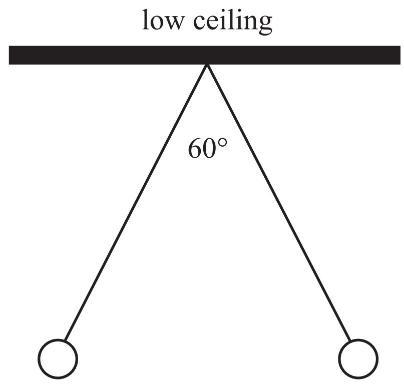


Figure 1

There are three forces acting on each ball:

- a tension force, T
- a gravitational force, F_g
- an electrostatic force, F_E.

a. On Figure 1, using the labels T, F_g and F_E, draw each of the three forces acting on each of the charged balls. 3 marks

b. Show that the tension force, T, in each string is 4.5×10^{-2} N. Use $g = 9.8$ N kg^{-1}.
Show your working. 2 marks

c. Calculate the magnitude of the electrostatic force, F_E. Show your working. 2 marks

N

Question 8 (7 marks)

Maia is at a skatepark. She stands on her skateboard as it rolls in a straight line down a gentle slope at a constant speed of 3.0 m s^{-1}, as shown in Figure 8. The slope is 5° to the horizontal.

The combined mass of Maia and the skateboard is 65 kg.

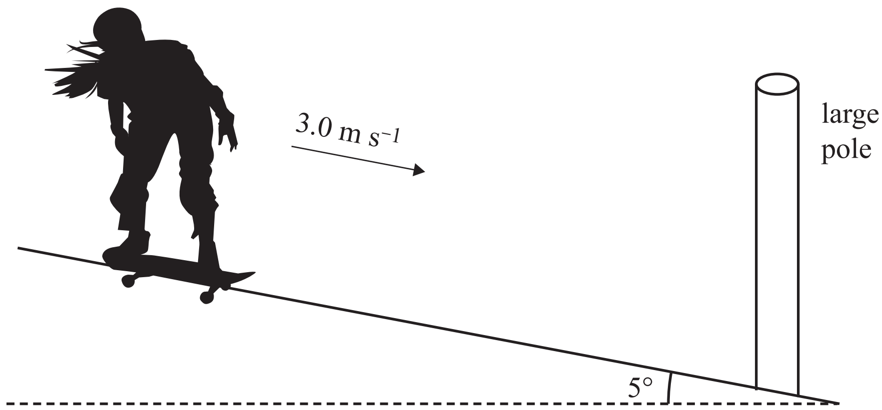


Figure 8

a. In Figure 9, the combined system of Maia and the skateboard is modelled as a small box with point M at the centre of mass.

Draw and label arrows to represent each of the forces acting on the system – that is, Maia and skateboard, as they roll down the slope. 3 marks

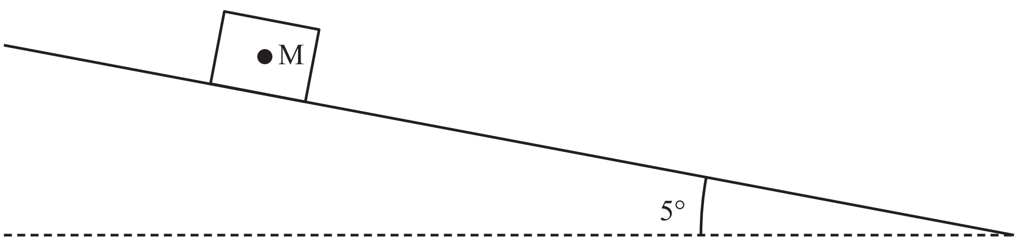


Figure 9

b. Calculate the magnitude of the total frictional forces acting on Maia and the skateboard. 2 marks

N