

Name of the Student: \_\_\_\_\_

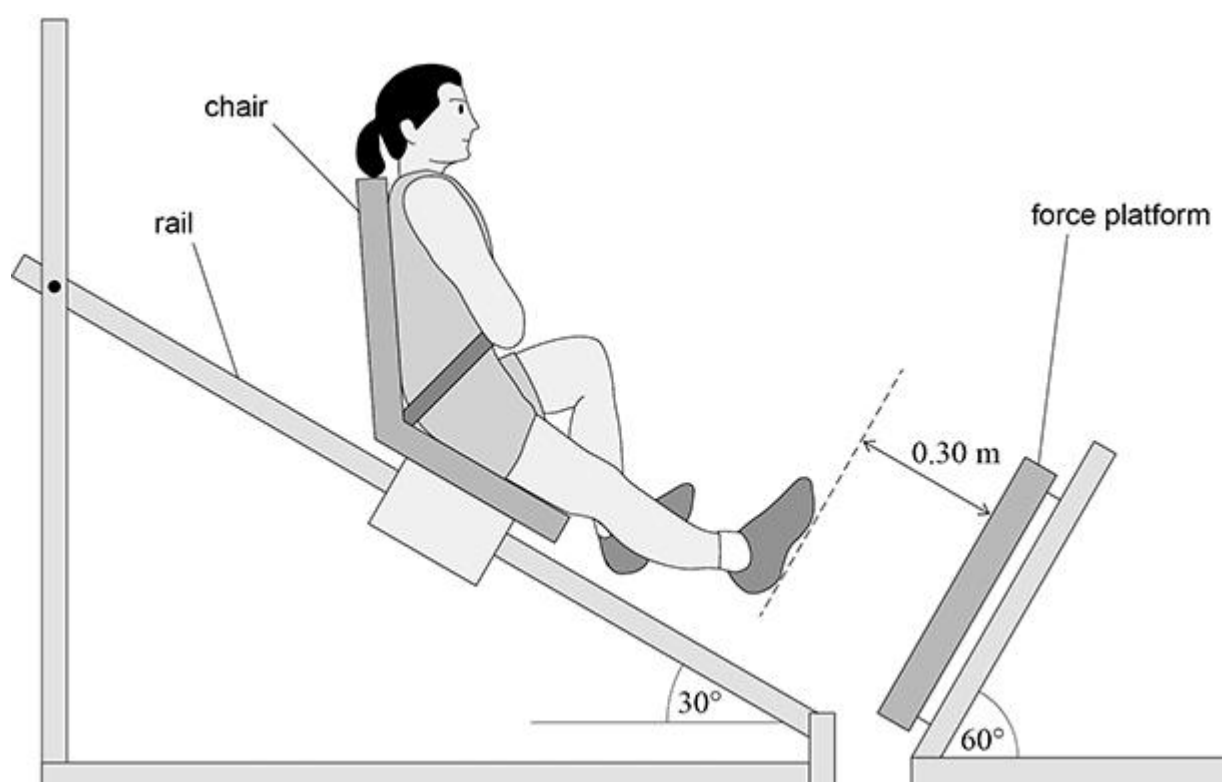
Max. Marks : 23 Marks

Time : 23 Minutes

Q1.

Figure 1 shows apparatus used to measure the force exerted by an athlete during a single-leg jump.

Figure 1



In Figure 1, the athlete is strapped into a chair and held at rest halfway along a rail. The chair is then released to slide down the rail. The athlete keeps her right leg extended until her right foot makes contact with a force platform.

Friction between the rail and the chair is negligible.

initial distance between right foot and platform = 0.30 m

angle between rail and floor =  $30^\circ$

angle between platform and floor =  $60^\circ$

- (a) Show that the athlete and chair accelerate towards the platform at approximately  $5 \text{ m s}^{-2}$ .

(b) Calculate the speed of the athlete when her right foot makes initial contact with the platform.

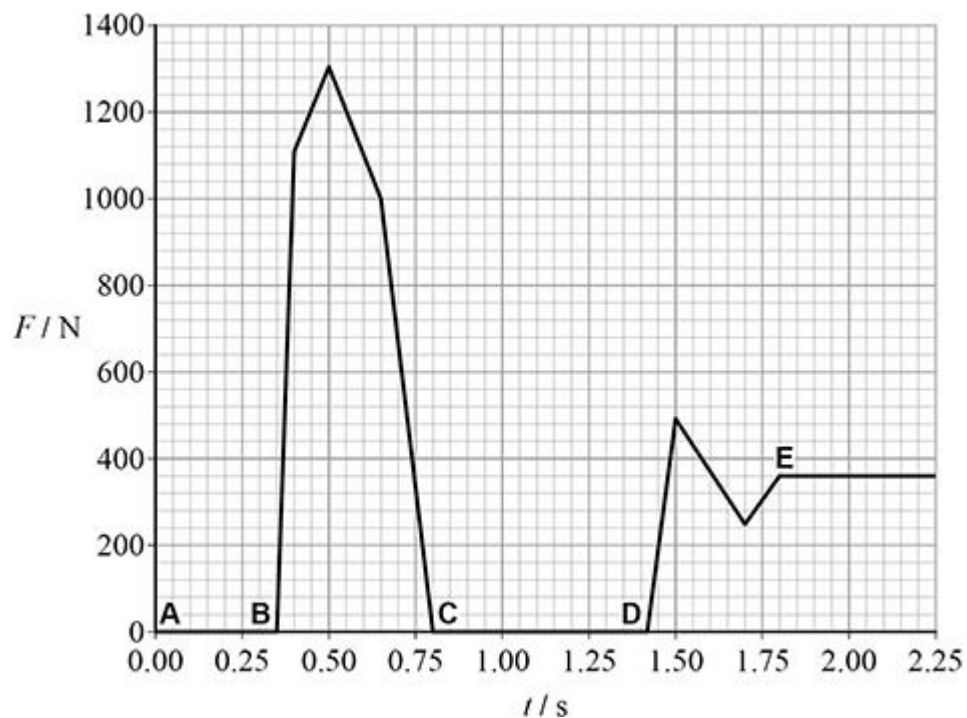
$$\text{speed} = \text{_____} \text{ m s}^{-1}$$

(2)

After her right foot makes contact with the platform, she uses her right leg to stop moving and then push herself back up the rail. She slides down the rail again, lands on the platform with both feet and comes to rest.

**Figure 2** shows the variation of force  $F$  on the platform with time  $t$  during the full motion.

**Figure 2**



The sequence below describes what happens at the five instances **A**, **B**, **C**, **D** and **E** shown in **Figure 2**.

- A:** athlete and chair are released at  $t = 0.00$  s
- B:** right foot of athlete contacts the platform with leg fully extended
- C:** right foot loses contact with the platform
- D:** athlete lands on the platform with both feet
- E:** athlete and chair come to rest

(c) Determine the impulse provided by the force platform between **B** and **C**.

$$\text{impulse} = \text{_____} \text{ N s} \quad (2)$$

(d) Determine the distance travelled by the athlete between **C** and **D**.

$$\text{distance travelled} = \text{_____} \text{ m} \quad (3)$$

(e) Determine, using **Figure 2**, the combined mass of the athlete and chair.

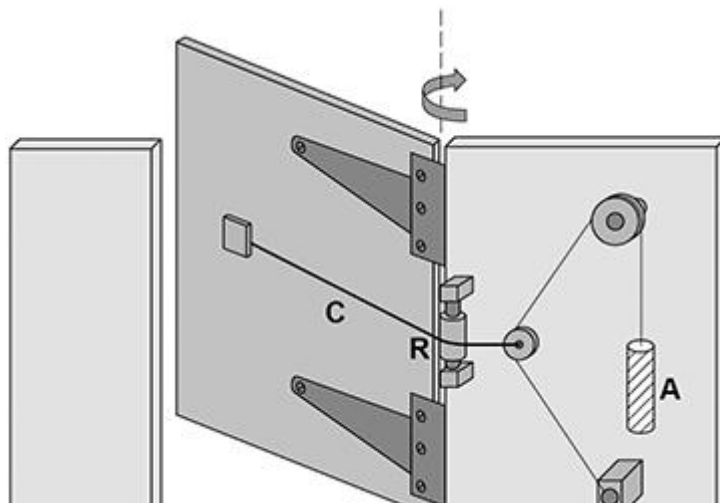
$$\text{mass} = \text{_____} \text{ kg} \quad (2)$$

**(Total 10 marks)**

**Q2.**

**Figure 1** shows a garden gate with a pulley system designed to close the gate.

**Figure 1**



The pulley system raises weight **A** when the gate is opened. When the gate is released, **A** falls. The horizontal cable **C** passes over pulley **R**. The tension in cable **C** causes the gate to close.

Weight **A** is a solid cylinder with the following properties:

$$\text{diameter} = 4.8 \times 10^{-2} \text{ m}$$

$$\text{length} = 0.23 \text{ m}$$

$$\text{weight} = 35 \text{ N}$$

The table below gives the density of three available materials.

Material	Density / $\text{kg m}^{-3}$
concrete	$2.4 \times 10^3$
iron	$7.8 \times 10^3$
brass	$8.6 \times 10^3$

(a) Deduce which **one** of the three materials is used for **A**.

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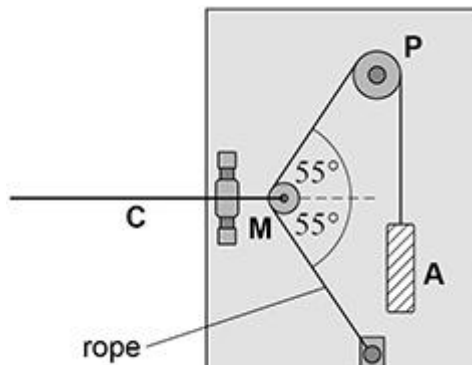


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(3)

**Figure 2** shows the pulley arrangement when the gate is closed.

**Figure 2**



Pulleys **P** and **M** are frictionless so that the tension in the rope attached to **A** is equal to the weight of **A**.  
**A** weighs 35 N and the weight of moveable pulley **M** is negligible.

(b) Calculate the tension in the horizontal cable **C** when the gate is closed.

tension = \_\_\_\_\_ N

(2)

(c) Pulley **M** is pulled to the left as the gate is opened.

Explain why this increases the tension in the horizontal cable **C**.

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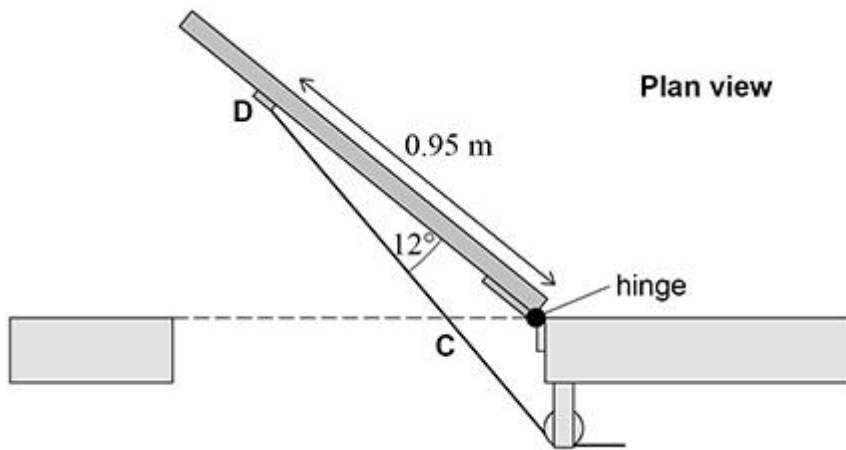
(2)

(d) **Figure 3** shows a plan view with the gate open. The horizontal cable **C** passes over pulley **R** and is attached to the door at **D**.

The angle between the door and the horizontal cable **C** is  $12^\circ$ .

The horizontal distance between the hinge and **D** is 0.95 m.

**Figure 3**



The tension in the horizontal cable **C** is now 41 N.

Calculate the moment of the tension about the hinge.

moment = \_\_\_\_\_ N m

(2)

- (e) The same system is attached to an identical gate with stiffer hinges. Now the system does not supply a sufficiently large moment to close the gate.

Discuss **two** independent changes to the design to increase the moment about the hinges due to horizontal cable **C**.

1 \_\_\_\_\_

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2 \_\_\_\_\_

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\_\_\_\_\_

(4)

(Total 13 marks)