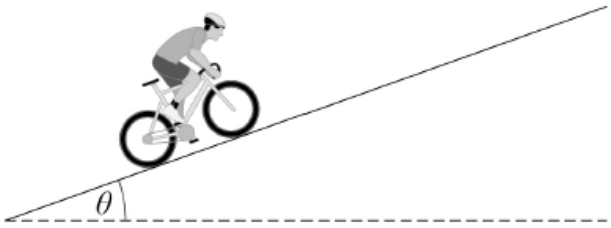
**Force, energy and momentum – AS Physics**

**1.** No.7

**0 7 . 1** **Figure 8** shows a cyclist going up a hill.

**Figure 8**




**not to scale**

The angle $\theta$ of the slope of the hill is constant.
The total mass $m$ of the cyclist and bicycle is $65\ \text{kg}$.

Write an expression for the component of the total weight parallel to the slope.

**[1 mark]**

_____

**0 7 . 2** The useful power output of the cyclist is $310\ \text{W}$.
The cyclist has a steady speed of $1.63\ \text{m s}^{-1}$.

Assume that air resistance is negligible at this speed.

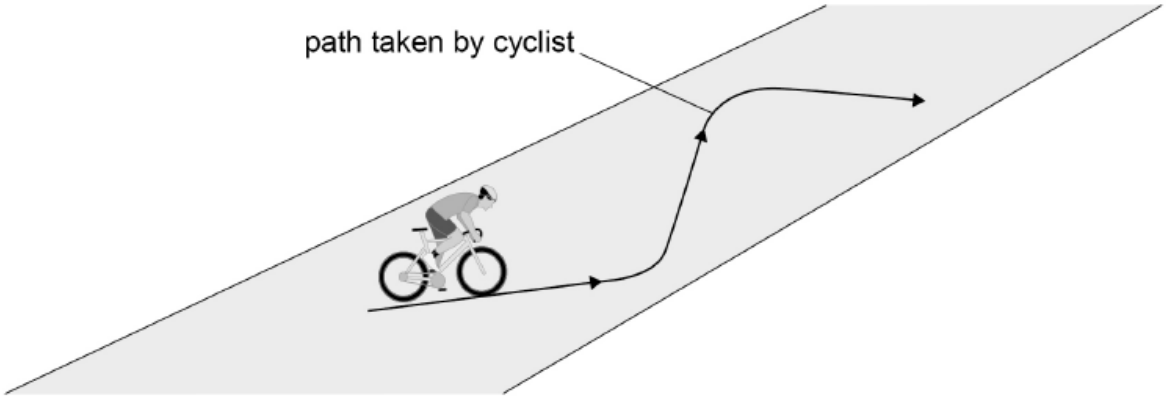
Calculate $\theta$.

**[2 marks]**

$\theta =$ _____ °

**Figure 9** shows an alternative 'zig-zag' path taken by the cyclist up the same hill. She maintains a steady speed of $1.63\ \text{m s}^{-1}$.

**Figure 9**



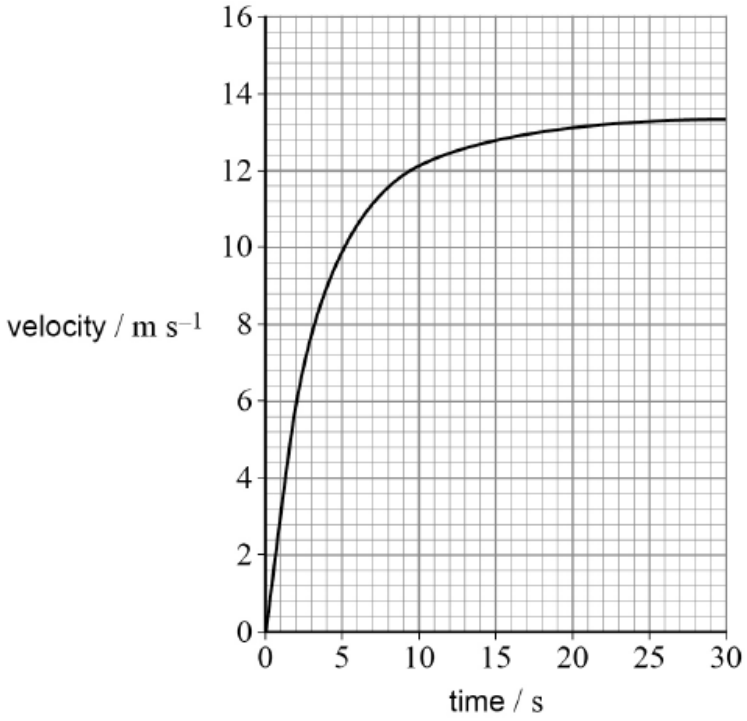

**0 7 . 3** Discuss how her useful power output when taking the path in **Figure 9** compares with her useful power output in Question **07.2**.

**[3 marks]**

The cyclist reaches the top of the hill. She then travels back down the hill in a straight line. The bicycle rolls freely without the cyclist pushing the pedals or applying the brakes.

**Figure 10** shows the variation of her velocity with time as she goes down the hill.

**Figure 10**




**0 7 . 4** Determine the acceleration of the cyclist 10.0 s after she begins to go down the hill.

**[3 marks]**

acceleration = _____ m s$^{-2}$

**0 7 . 5** Energy transfers occur as the cyclist travels down the hill.

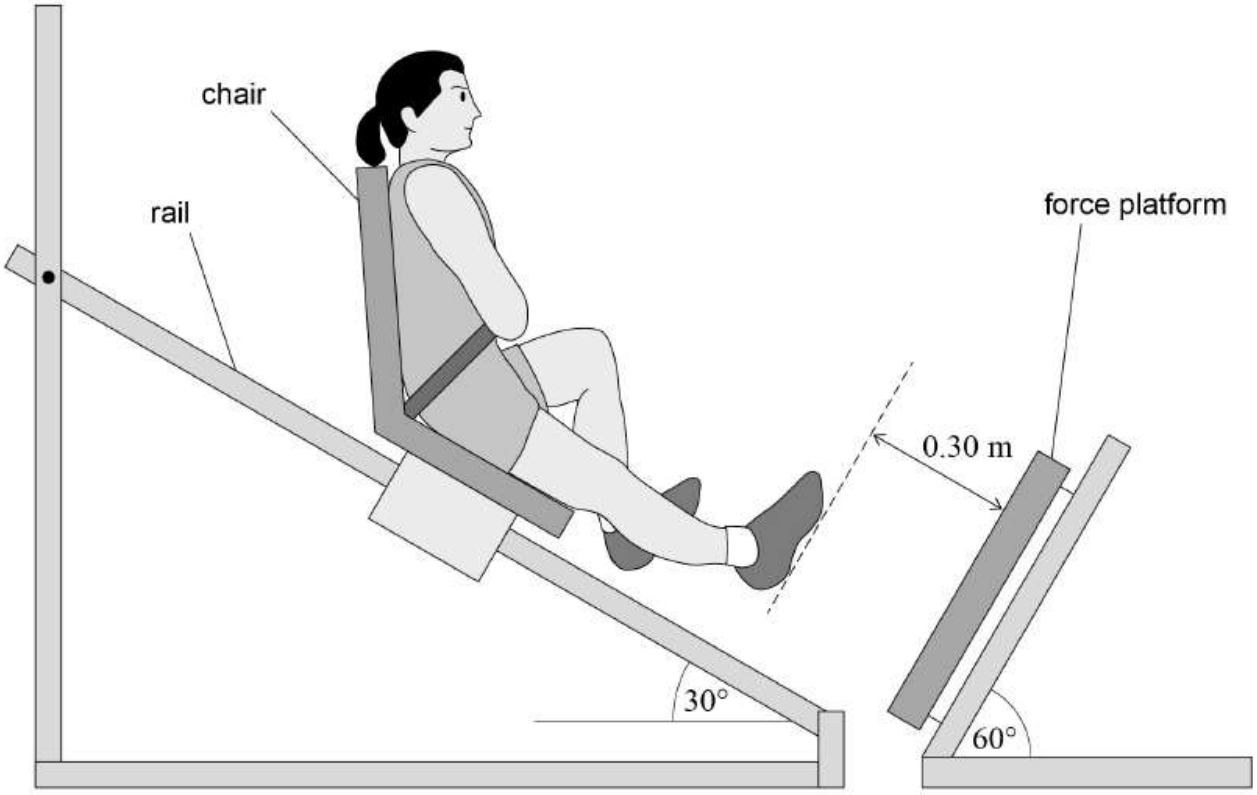
Outline how these energy transfers explain the shape of the graph in **Figure 10**.

**[4 marks]**

**2.** No.4

**0 4** **Figure 6** shows apparatus used to measure the force exerted by an athlete during a single-leg jump.

**Figure 6**




In **Figure 6**, 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°
angle between platform and floor = 60°

**0 4 . 1** Show that the athlete and chair accelerate towards the platform at approximately 5 m $s^{-2}$.

**[1 mark]**

**0 4 . 2** Calculate the speed of the athlete when her right foot makes initial contact with the platform.

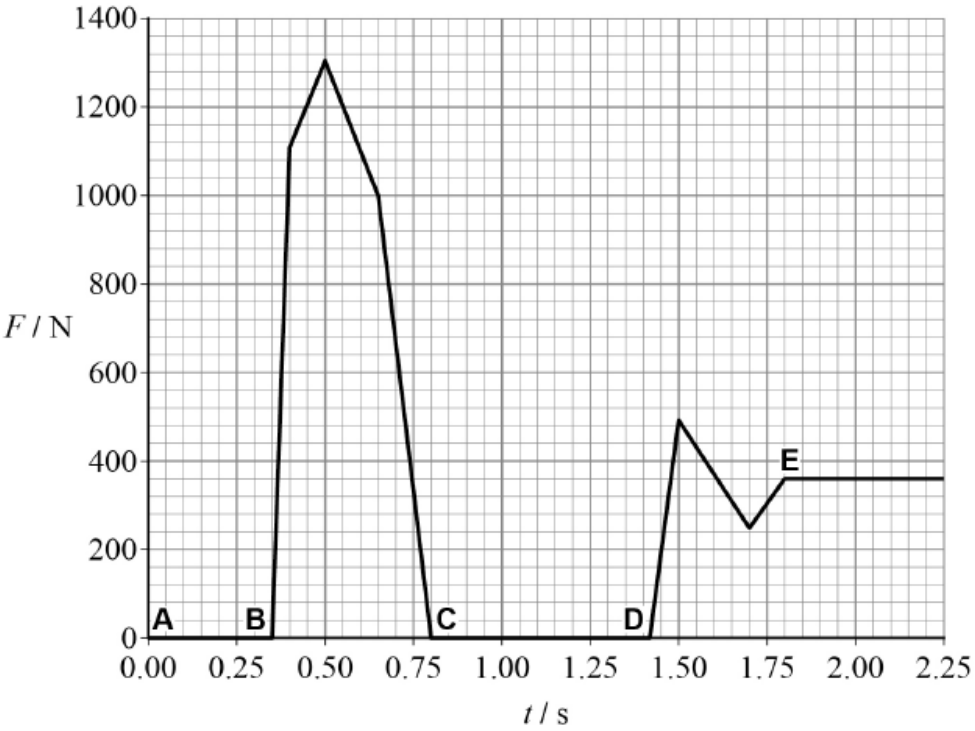
**[2 marks]**

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

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

**Figure 7**




The sequence below describes what happens at the five instances **A**, **B**, **C**, **D** and **E** shown in **Figure 7**.

**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

**0 4 . 3** Determine the impulse provided by the force platform between **B** and **C**.

**[2 marks]**

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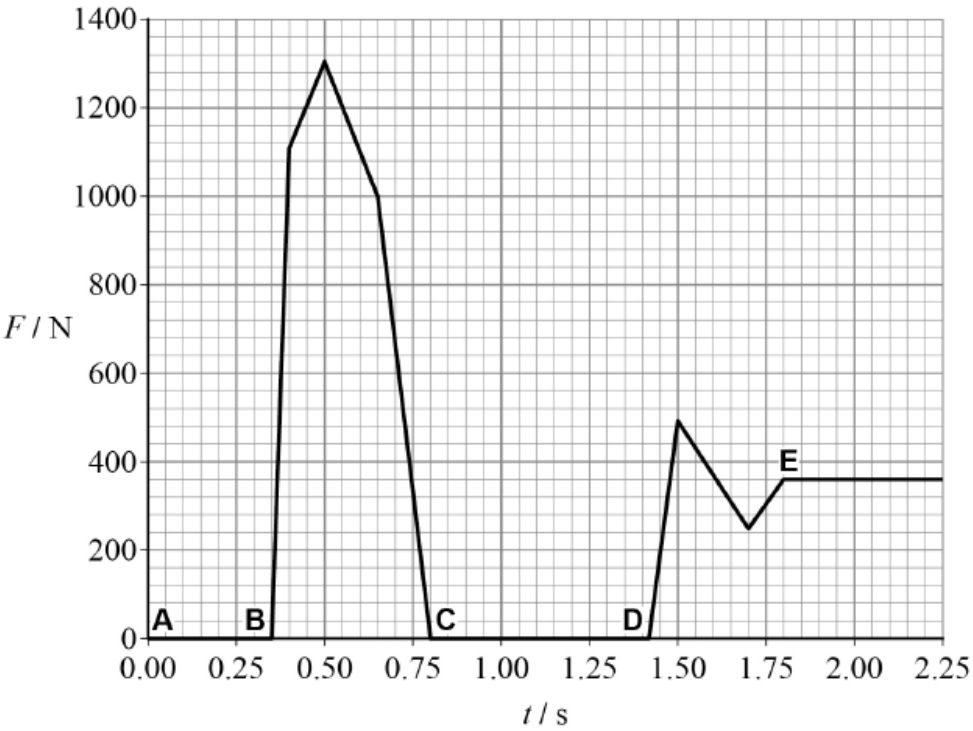
**Figure 7**




The sequence below describes what happens at the five instances **A**, **B**, **C**, **D** and **E** shown in **Figure 7**.

**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

**0 4 . 3** Determine the impulse provided by the force platform between **B** and **C**.

**[2 marks]**

impulse = _____ N s

**0 4 . 4** Determine the distance travelled by the athlete between **C** and **D**.

**[3 marks]**

distance travelled = _____ m

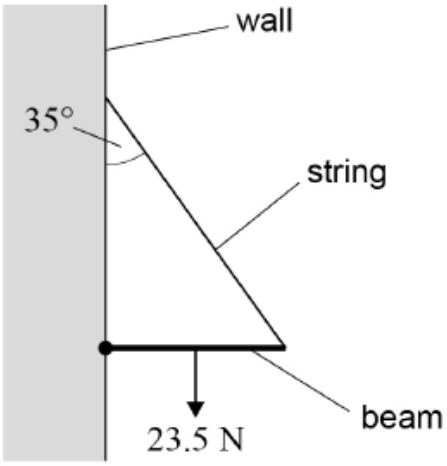
**0 4 . 5** Determine, using **Figure 7**, the combined mass of the athlete and chair.

**[2 marks]**

mass = _____ kg

**3.** No.22

A uniform beam of weight 23.5 N is attached by a hinge to a vertical wall and supported by a string.
The string makes an angle of 35° to the wall.




What is the tension in the string?

**[1 mark]**

**A** 14 N ⬭

**B** 21 N ⬭

**C** 29 N ⬭

**D** 41 N ⬭

**4.** No.23

Which description of a couple and its unit is correct?

**[1 mark]**

| | Description | Unit | |
|---|---|---|---|
| **A** | consists of two equal parallel forces | $\mathrm{N\,m^{-1}}$ | ⬭ |
| **B** | produces translational motion | $\mathrm{N\,m}$ | ⬭ |
| **C** | consists of two equal and opposite forces | $\mathrm{N\,m}$ | ⬭ |
| **D** | produces rotational motion | $\mathrm{N\,m^{-1}}$ | ⬭ |

**5.** No.24

**P** and **Q** are two balls of the same diameter. **P** has a greater mass than **Q**.

Both balls are projected at the same time from the top of a tall building that stands on horizontal ground.
Both balls are projected with the same horizontal velocity.
**P** reaches the ground after time $t_P$ and at a horizontal distance $d_P$ from the building.
**Q** reaches the ground after time $t_Q$ and at a horizontal distance $d_Q$ from the building.

The air is still and air resistance is **not** negligible.

Which row is correct?

**[1 mark]**

| | Time | Horizontal distance | |
|---|---|---|---|
| **A** | $t_P = t_Q$ | $d_P = d_Q$ | ⬭ |
| **B** | $t_P = t_Q$ | $d_P > d_Q$ | ⬭ |
| **C** | $t_P < t_Q$ | $d_P = d_Q$ | ⬭ |
| **D** | $t_P < t_Q$ | $d_P > d_Q$ | ⬭ |

**6.** No.25

A firework rocket moves vertically upwards.
The rocket's fuel burns at a steady rate to produce a constant thrust.
The mass of the rocket decreases with time.

Ignore the effects of air resistance on the rocket.

Which row shows the acceleration of the rocket before, and the acceleration immediately after, the fuel has been used up?

**[1 mark]**

| | Acceleration before | Acceleration immediately after | |
|---|---|---|---|
| **A** | increasing upwards | constant downwards | ⬭ |
| **B** | increasing upwards | decreasing upwards | ⬭ |
| **C** | constant upwards | constant downwards | ⬭ |
| **D** | decreasing upwards | constant downwards | ⬭ |

**7.** No.26

Object **P** has a mass of $7500\ \text{kg}$ and travels at $12\ \text{m s}^{-1}$.
Object **Q** has a mass of $2500\ \text{kg}$ and travels at $20\ \text{m s}^{-1}$ in the same direction as **P**.
**P** and **Q** collide and remain together after the collision.

What is the total kinetic energy of **P** and **Q** immediately after the collision?

**[1 mark]**

**A** $70\ \text{kJ}$ ⬭

**B** $140\ \text{kJ}$ ⬭

**C** $980\ \text{kJ}$ ⬭

**D** $2.0\ \text{MJ}$ ⬭