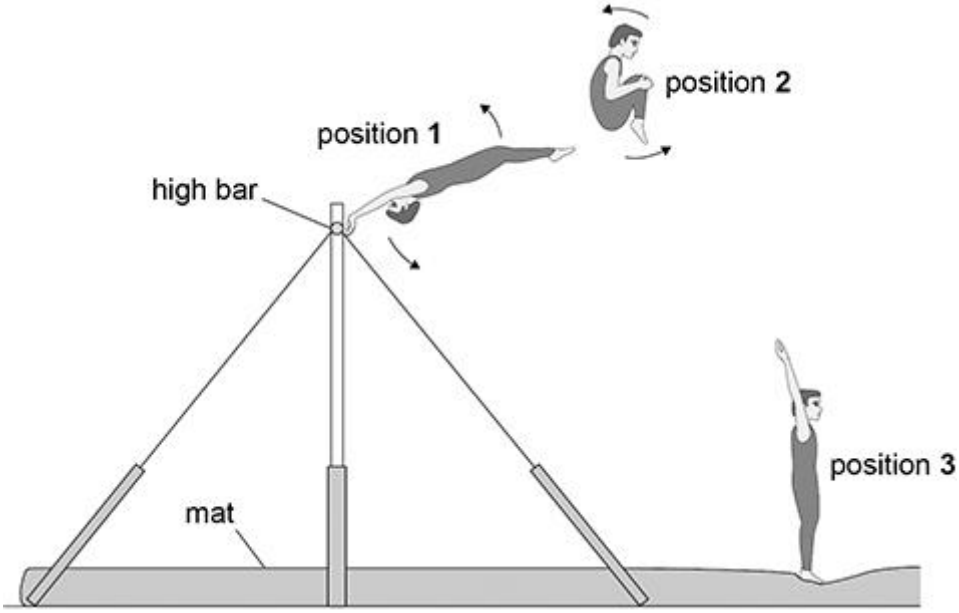
Name of the Student:_____
Max. Marks : 18 Marks **Time : 18 Minutes**

Q1.

A gymnast dismounts from an exercise in which he swings on a high bar. The gymnast rotates in the air before landing.

The figure below shows the gymnast in three positions during the dismount.



The arrows show the direction of rotation of the gymnast.

In position **1** the gymnast has just let go of the bar. His body is fully extended.

Position **2** shows the rotating gymnast a short time later. His knees have been brought close to his chest into a 'tuck'.

Position **3** is at the end of the dismount as the gymnast lands on the mat. His body is once again fully extended.

(a) Explain why the moment of inertia about the axis of rotation decreases when his knees are moved towards his chest.
Go on to explain the effect this has on his angular speed.

_____

_____

_____

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_____

_____

_____

(3)

The table below gives some data about the gymnast in position **1** and in position **2**.

Position	Moment of inertia / kg m^2	Angular speed / rad s^{-1}
1	13.5	ω
2	4.1	14.2

(b) Calculate the angular speed ω of the gymnast in position **1**.

ω = _____ rad s^{-1}

(1)

(c) The gymnast stays in the tuck for 1.2 s.

Determine the number of **complete** rotations performed by the gymnast when in the tuck during the dismount.

number of complete rotations = _____

(2)

(d) The gymnast repeats the exercise. The height of the bar remains unchanged.

State and explain **two** actions the gymnast can take to complete more rotations during the dismount.

1 _____

_____

_____

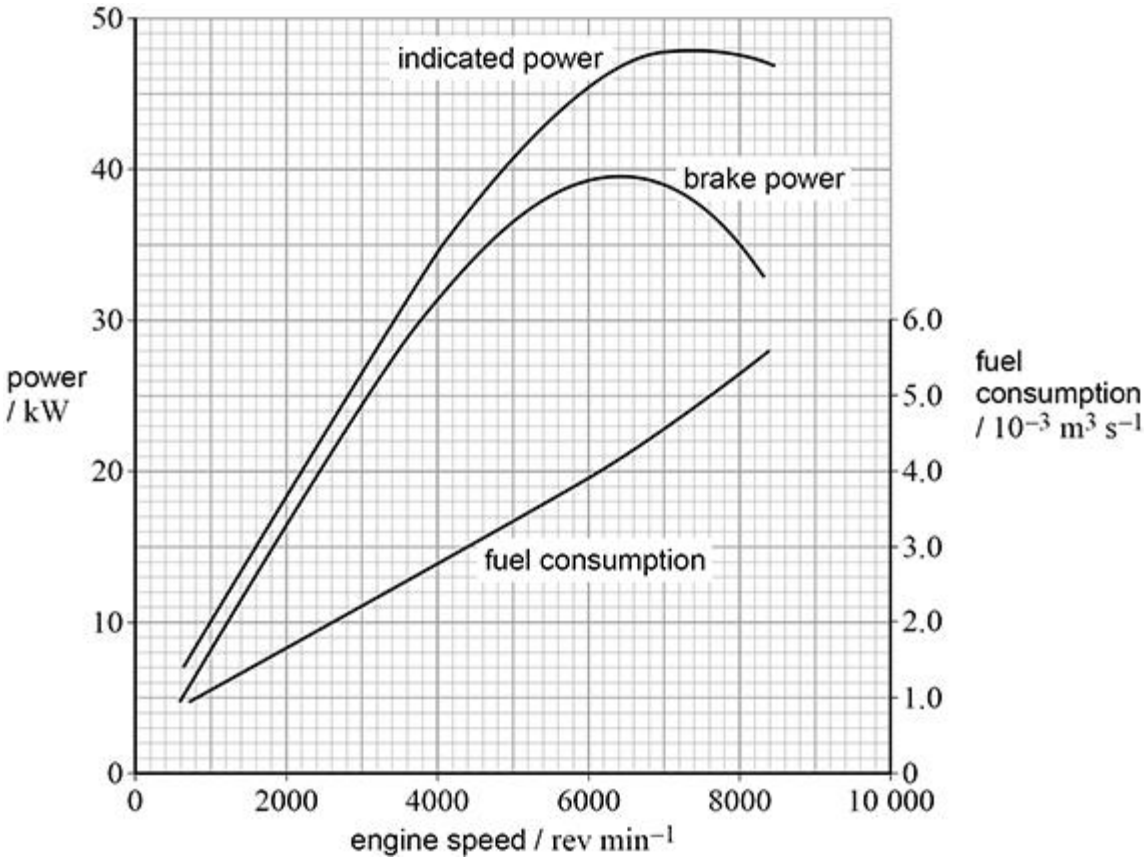
_____

2 _____

(4)
(Total 10 marks)

Q2.

The figure below shows the results of a test on an internal combustion engine which uses purified biogas.



The figure above shows how the indicated power, brake (or output) power and fuel consumption of the engine vary with the engine speed. The scale on the left-hand axis is power and the scale on the right-hand axis is fuel consumption.

(a) The figure above can be used to analyse the performance of the engine.

Determine, for the speed at which the engine develops its maximum brake power:

- the overall efficiency
- the thermal efficiency

- the mechanical efficiency.

Go on to explain how knowledge of these efficiencies can be useful to an engineer.

calorific value of biogas used in the test = 32.3×10^6 J m^{-3}

(6)

(b) Explain why it is **not** advisable to run this engine at speeds above 7000 rev min^{-1}. Refer to the figure above in your answer.

(2)
(Total 8 marks)