Practice Question Set For A-Level
Subject : Physics
Paper-3 Topic: Section B (Section 11_ Engineering Physics)

Name of the Student:____

Max. Marks : 26 Marks **Time : 26 Minutes**

Q1.

(a) The first law of thermodynamics can be written as:

$$Q = \Delta U + W$$

State what Q represents in this equation.

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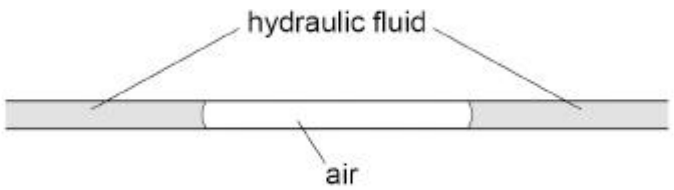
(1)

Air in the brake pipe of a bicycle hydraulic brake system can be dangerous.
The figure below shows a bubble of air in a brake pipe.



Assume that the hydraulic fluid is incompressible.
During a sudden application of the brake, the air is compressed adiabatically to a high pressure.

(b) The work done on the air when it is compressed is 10.8 mJ.

Which row is correct for this adiabatic compression?

Tick ✓ **one** box.

W / mJ	Q / mJ	ΔU / mJ	
−10.8	0	10.8	☐
10.8	10.8	0	☐
−10.8	−10.8	0	☐
10.8	0	−10.8	☐

(1)

(c) The initial conditions for the air are:

volume of air = 2.91×10^{-8} m^3
pressure of air = 1.05×10^5 Pa
temperature of air = 293 K.

During sudden braking, the air in the bubble is compressed adiabatically to a volume of 3.19×10^{-9} m^3.

Calculate the pressure and the temperature of the air immediately after the compression.

γ for air = 1.4

pressure = ____________________ Pa

temperature = ____________________ K

(3)

(d) To produce the adiabatic change, the brake lever is pulled very quickly.
The cyclist thinks that by applying the brake slowly, the work done to compress the bubble to a volume of 3.19×10^{-9} m^3 will be greater than 10.8 mJ.

Deduce without calculation whether the cyclist is correct.

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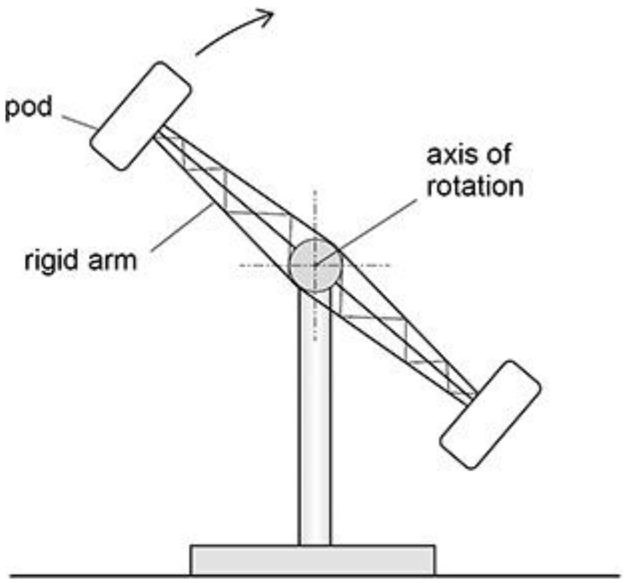
(2)

(Total 7 marks)

Q2.

Figure 1 shows a fairground ride.

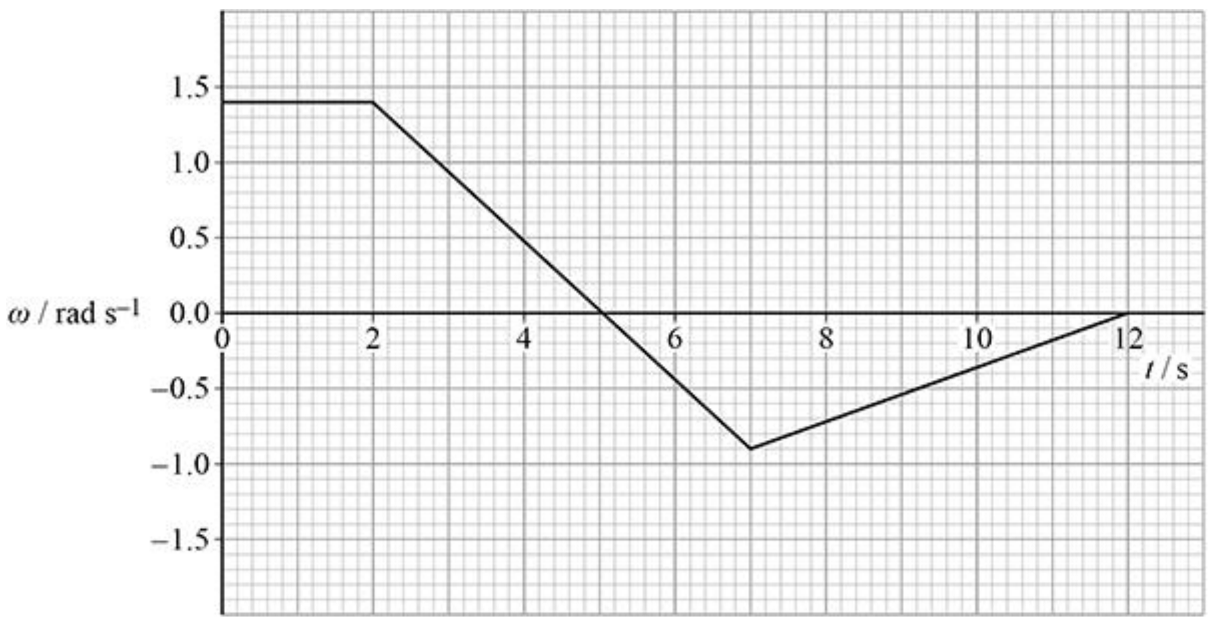
Figure 1



The ride consists of a rotor that rotates in a vertical circle about a horizontal axis.
The rotor has two rigid arms. A pod containing passengers is attached to each arm.
The rotor is perfectly balanced.
The direction of rotation of the rotor is reversed at times during the ride.

Figure 2 shows the variation of the angular velocity ω of the rotor with time t during a 12 s period.

Figure 2



(a) Determine the mean angular velocity of the rotor during the 12 s period.

mean angular velocity = _______________ rad s^{-1}

(2)

The moment of inertia of the rotor about its axis of rotation is 2.1×10^4 kg m^2.
A constant frictional torque of 390 N m acts at the bearings of the rotor.

(b) Calculate the power output of the driving mechanism during the first 2 s shown in **Figure 2**.

power output = _______________ W

(1)

(c) Calculate the maximum torque applied by the driving mechanism to the rotor during the 12 s period.

maximum torque = _______________ N m

(3)

(d) Calculate the magnitude of the angular impulse on the rotor between t = 2.0 s and t = 7.0 s.

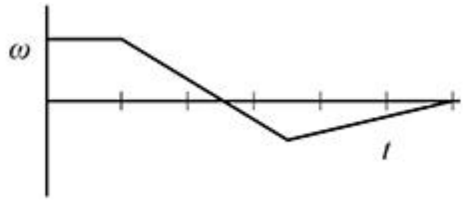
angular impulse = _______________ N m s

(1)

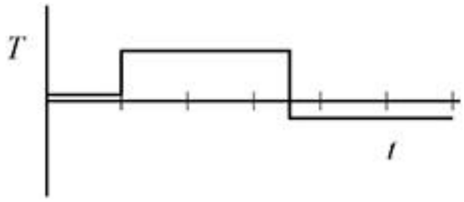
(e) Which graph best shows the variation of the torque T applied to the rotor for the 12 s period?

Tick (✓) **one** box.

A copy of **Figure 2** is provided to help you.



copy of **Figure 2**



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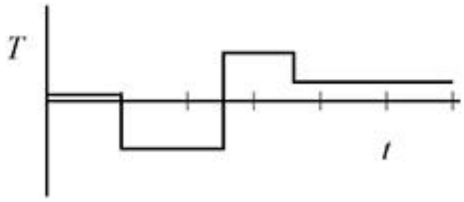

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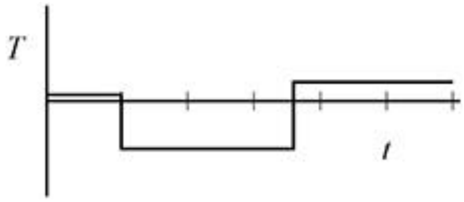

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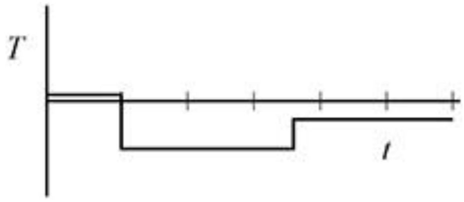

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(1)
(Total 8 marks)

Q3.

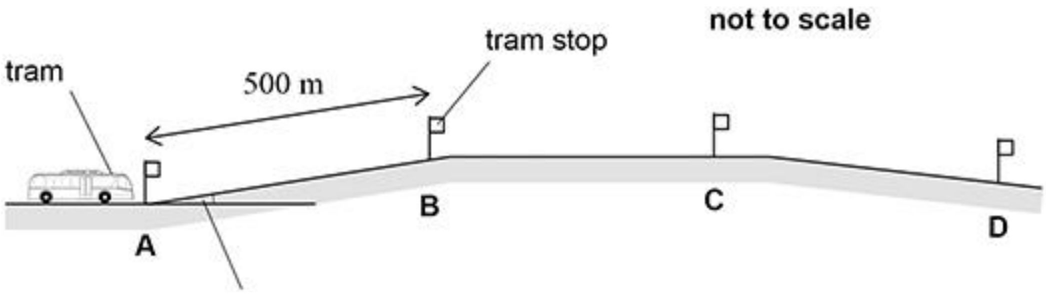
A moving tram is powered by energy stored in a rapidly spinning flywheel.

When the tram is at a tram stop, the flywheel is 'charged' by being accelerated to a high rotational speed.

The mass of the tram, flywheel and passengers is 1.46×10^4 kg.

The distance between tram stops is 500 m.

The figure below shows that between stops **A** and **B** the track is inclined at a constant 5.0° to the horizontal.



The tram must travel 500 m along this incline on one charge of energy.

The total resistive force on the tram due to its motion is constant at 1.18 kN.

The flywheel is a solid steel disc of diameter 1.00 m. It has a moment of inertia of 62.5 kg m^2.

(a) Calculate the minimum angular speed of the flywheel when the tram leaves stop **A** so that the tram reaches stop **B** using only energy stored in the flywheel.

minimum angular speed = _______________ rad s^{-1}

(3)

(b) Between stops **C** and **D** the tram travels downhill.

Suggest **two** advantages of keeping the flywheel connected to the driving wheels when the tram travels downhill.

1. ____

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2. ____

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(2)

(c) The same tram is to be used on a track where the stops are further apart, so the flywheel system needs to be modified.

Discuss the design features of the flywheel that will enable it to store more energy without increasing the mass of the tram.

In your answer you should consider:

- the design of the flywheel
- how the choice of materials used to make the flywheel is influenced by its design and maximum angular speed
- other design aspects that allow for high angular speeds of the flywheel.

(6)
(Total 11 marks)