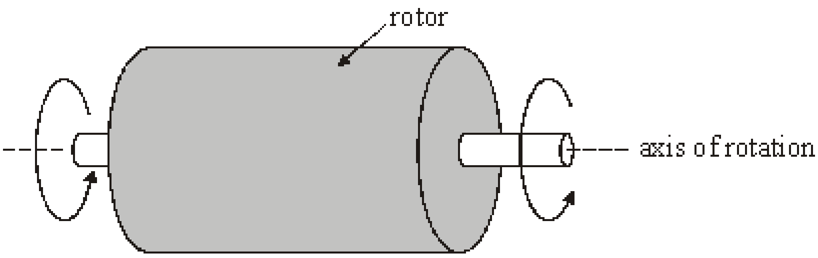
Practice Question Set For A-Level
Subject : Physics
Paper-3 Topic: Section B (Section 11_ Engineering Physics)

Name of the Student:____

Max. Marks : 23 Marks **Time : 23 Minutes**

Q1.

'Low inertia' motors are used in applications requiring rapid changes of speed and direction of rotation. These motors are designed so that the rotor has a very low moment of inertia about its axis of rotation.



(a) (i) Explain why a low moment of inertia is desirable when the speed and direction of rotation must be changed quickly.

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(ii) State, giving a reason in each case, **two** features of rotor design which would lead to a low moment of inertia about the axis of rotation.

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(4)

(b) In one application, a rotor of moment of inertia 4.4×10^{-5} kg m^2 about its axis of rotation is required to reverse direction from an angular speed of 120 rad s^{-1} to the same speed in the opposite direction in a time of 50 ms. Assuming that the torque acting is constant throughout the change, calculate

(i) the angular acceleration of the rotor,

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(ii) the torque needed to achieve this acceleration,

(iii) the angular impulse given to the rotor during the time the torque is acting,

(iv) the angle turned through by the rotor in coming to rest momentarily before reversing direction.

(4)
(Total 8 marks)

Q2.

An early form of four-stroke gas engine stores kinetic energy in a large flywheel driven by the crankshaft. The engine is started from rest with its load disconnected and produces a torque which accelerates the flywheel to its off-load running speed of 110 rev min^{-1}.

(a) The flywheel has a moment of inertia of 150 kg m^2 and takes 15 s to accelerate from rest to an angular speed of 110 rev min^{-1}.

(i) Show that the rotational kinetic energy stored in the flywheel at this speed is approximately 10 kJ.

(ii) Calculate the average useful power output of the engine during the acceleration.

(iii) Use your answer to part (ii) to calculate the average net torque acting on the flywheel during the acceleration.

(5)

(b) When the engine is running at 110 rev min^{-1} off-load, the gas supply to the engine is suddenly cut off and the flywheel continues to rotate for a further 35 complete turns before coming to rest. Calculate the average retarding torque acting on the flywheel.

(2)
(Total 7 marks)

Q3.

Figure 1 shows a 'firewheel' used at a firework display. Thrust produced by the captive rockets creates a torque which rotates the beam about a horizontal pivot at its centre. The shower of brilliant sparks in the exhaust gases of the rapidly orbiting rockets creates the illusion of a solid wheel.

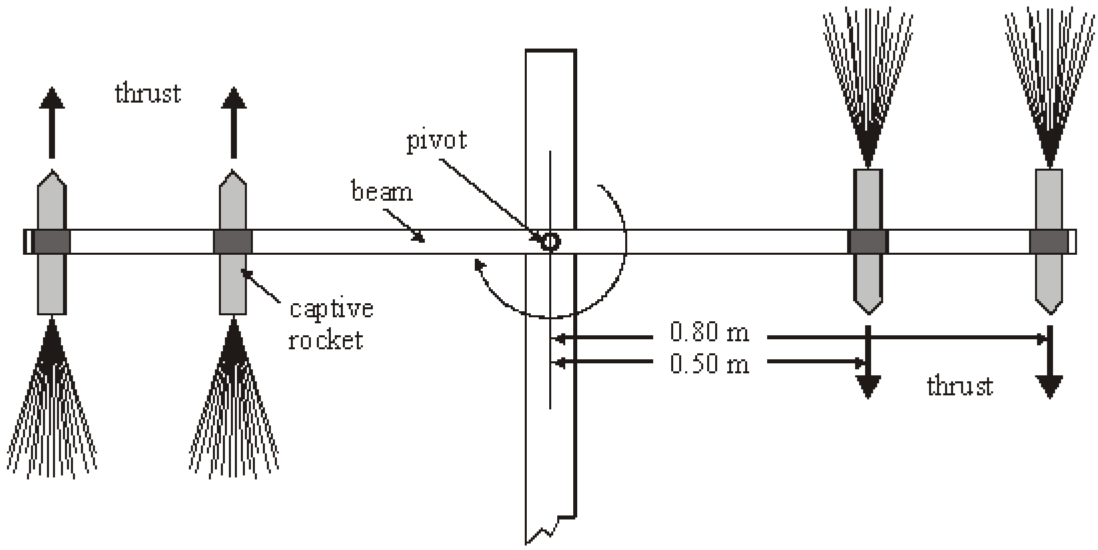

Figure 1

(a) The rockets are fixed symmetrically about the pivot at distances of 0.50 m and 0.80 m from the pivot. The initial mass of each rocket is 0.54 kg and the moment of inertia of the beam about the pivot is 0.14 kg m^2.

Show that the initial moment of inertia of the firewheel about the pivot is 1.10 kg m^2.

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(2)

(b) The rockets are ignited simultaneously and each produces a constant thrust of 3.5 N. The frictional torque at the pivot is negligible. Calculate

(i) the total torque about the pivot when all the rockets are producing thrust,

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(ii) the initial angular acceleration of the firewheel,

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(iii) the time taken for the firewheel to make its first complete turn, starting from rest.

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(4)

(c) The total thrust exerted by the rockets remains constant as the firewheel accelerates. Explain why, after a short time, the firewheel is rotating at a constant angular speed which is maintained until the rocket fuel is exhausted.

(2)

(Total 8 marks)