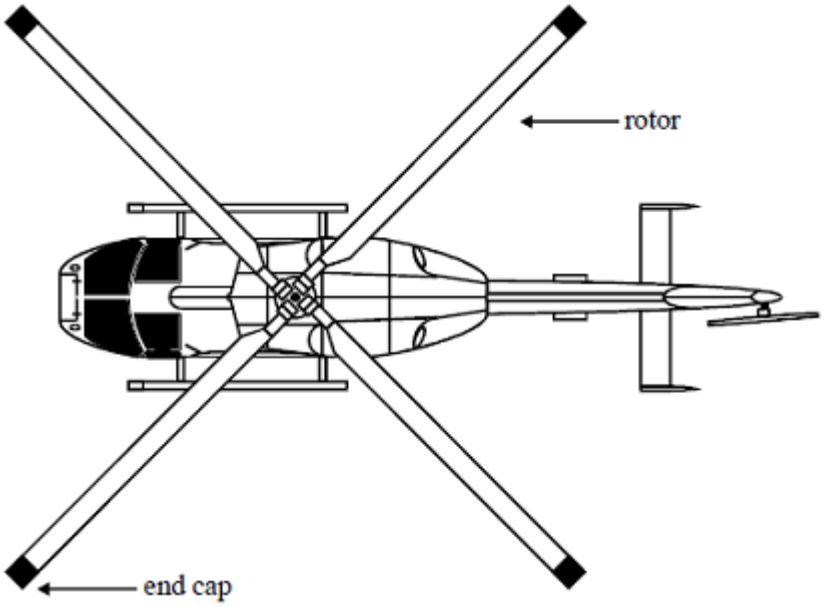
Name of the Student:_____
Max. Marks : 24 Marks **Time : 24 Minutes**

Q1.

The diagram below shows the rotor-blade arrangement used in a model helicopter. Each of the blades is 0.55 m long with a uniform cross-sectional area of 3.5×10^{-4} m^2 and negligible mass. An end-cap of mass 1.5 kg is attached to the end of each blade.



(a) (i) Show that there is a force of about 7 kN acting on each end-cap when the blades rotate at 15 revolutions per second.

(3)

(ii) State the direction in which the force acts on the end-cap.

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(1)

(iii) Show that this force leads to a longitudinal stress in the blade of about 20 MPa.

(2)

(iv) Calculate the change in length of the blade as a result of its rotation.

Young modulus of the blade material = 6.0×10^{10} Pa

(2)

(v) Calculate the total strain energy stored in one of the blades due to its extension.

(2)

(b) The model helicopter can be made to hover above a point on the ground by directing the air from the rotors vertically downwards at speed v.

(i) Show that the change in momentum of the air each second is $A\rho v^2$, where A is the area swept out by the blades in one revolution and ρ is the density of air.

(2)

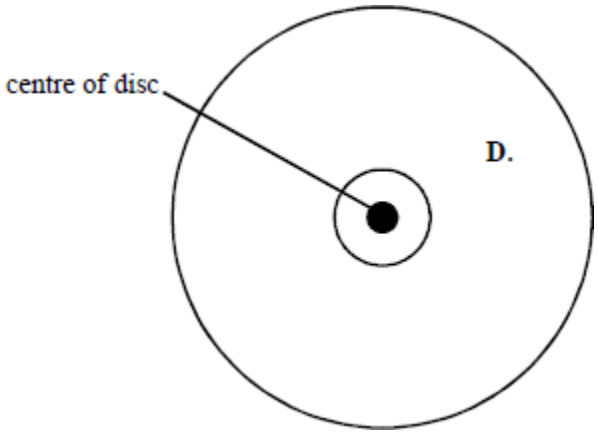
(ii) The model helicopter has a weight of 900 N. Calculate the speed of the air downwards when the helicopter has no vertical motion.

Density of air = 1.3 kg m^{-3}

(3)
(Total 15 marks)

Q2.

The figure below shows a dust particle at position **D** on a rotating vinyl disc. A combination of electrostatic and frictional forces act on the dust particle to keep it in the same position.



The dust particle is at a distance of 0.125 m from the centre of the disc. The disc rotates at 45 revolutions per minute.

(a) Calculate the linear speed of the dust particle at **D**.

(3)

(b) (i) Mark on the diagram above an arrow to show the direction of the resultant horizontal force on the dust particle.

(1)

(ii) Calculate the centripetal acceleration at position **D**.

(2)

(c) On looking closely at the rotating disc it can be seen that there is more dust concentrated on the inner part of the disc than the outer part. Suggest why this should be so.

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(3)

(Total 9 marks)