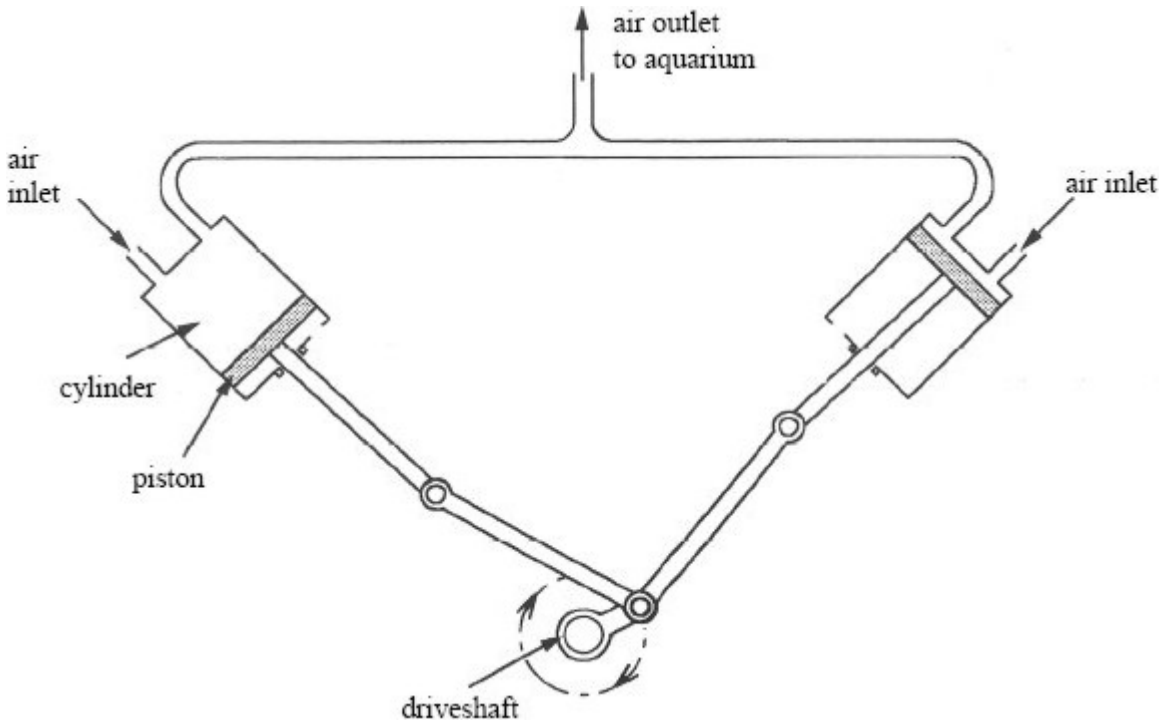
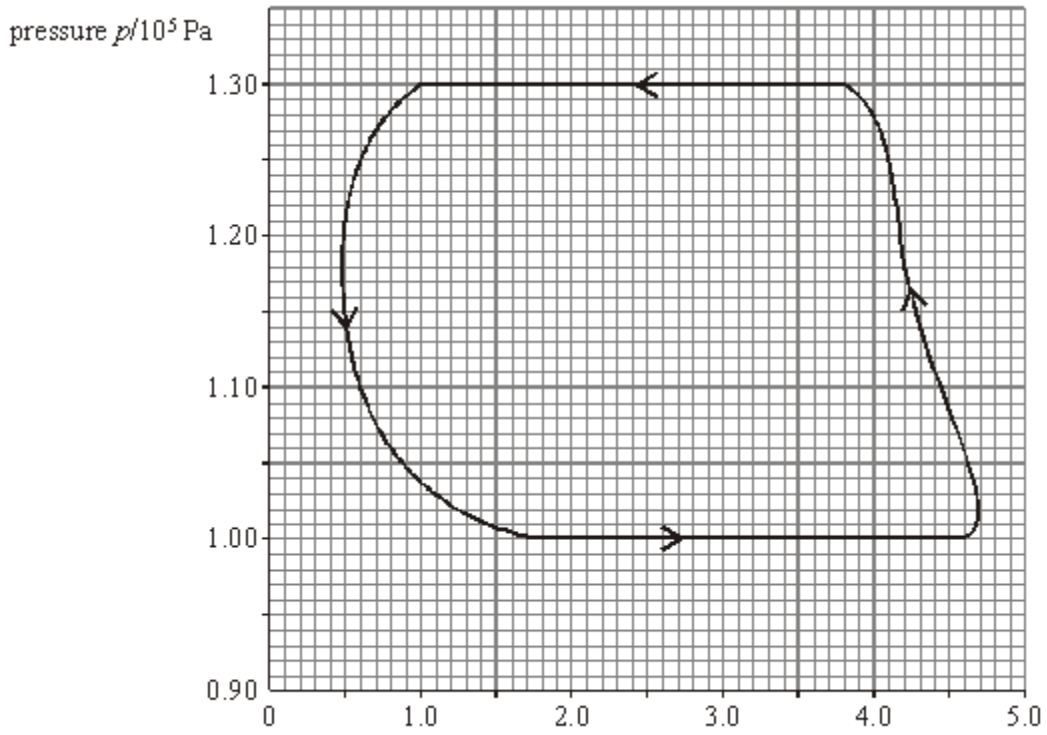
Name of the Student:_____

Max. Marks : 16 Marks **Time : 16 Minutes**

Q1.

A small, two-cylinder pump shown in the diagram is used for aerating water in an aquarium. The two cylinders are identical and each has a piston driven by a rotating driveshaft so that both cylinders pump air to the aquarium during one rotation of the driveshaft. The inlet and outlet valves controlling the airflow are not shown.





Air at a pressure of 1.00×10^5 Pa is drawn into the cylinders, is compressed and exhausted to an underwater outlet in the aquarium, where it is released as a stream of bubbles. The graph shows the *p*-*V* diagram for one cycle of one cylinder.

(a) Use the graph to determine the outlet pressure of the air from the pump.

_____

(1)

(b) Estimate

(i) the net work done on the air in one cylinder during one revolution of the driveshaft,

_____

_____

_____

_____

_____

(ii) the power input to the pump if the driveshaft rotates at 360 rev min^{-1}.

_____

_____

_____

_____

(6)

(c) Give **one** reason why the motor driving the pump would need to have a greater power than your answer to part (b)(ii).

_____

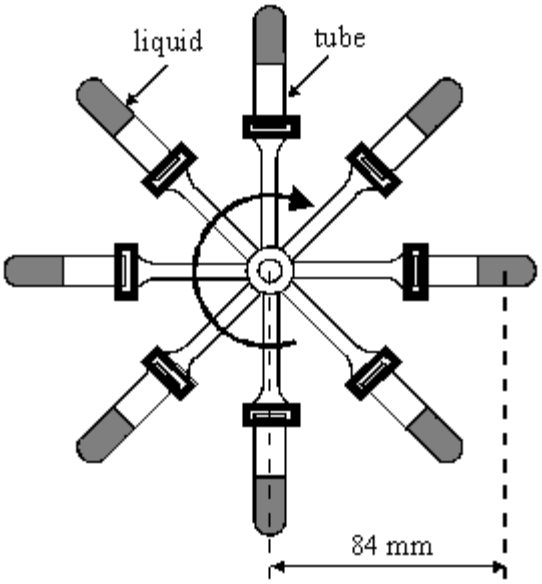
_____

(1)

(Total 8 marks)

Q2.

The diagram shows an overhead view of the load carrier of a spinning centrifuge, used to separate solid particles from the liquid in which they are suspended.



(a) When the centrifuge is operated with empty tubes, it reaches its working angular speed of 1100 rad s^{-1} in a time of 4.2 s, starting from rest. The moment of inertia of this system is 7.6 × 10^{-4} kg m^2. Calculate

(i) the angular acceleration of the system,

_____

_____

(ii) the torque required to produce this angular acceleration.

_____

(2)

(b) In normal operation, each of the eight tubes contains 3.0 × 10^{-3} kg of liquid, whose centre of mass, when spinning, is 84 mm from the axis of rotation. The torque produced by the motor is the same as when the tubes are empty.

Show that this system takes approximately 5 s to reach its working speed of 1100 rad s^{-1}, starting from rest.

_____

_____

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_____

(3)

(c) The normal operating cycle of the centrifuge takes a total time of 1 min. The centrifuge accelerates uniformly during the first 5.0 s to a speed of 1100 rad s^{-1}, after which the speed remains constant until the final 6.0 s of the cycle, during which it is brought to rest uniformly. Calculate the angle turned by a tube during one complete operating cycle.

(3)

(Total 8 marks)