

Name:

Duration: 15 min

ID:

Grade: ...../30

### Questions

#### Part I: Understand

(5 pts) Draw a sample *pressure vs air flow* curve of a fan. Explain how air flow rate control is achieved using damper control methods.

(5 pts) Draw a set of *pressure vs air flow* curves of a fan at different motor speeds. Explain how air flow rate control is achieved using VFD control.

#### Part II: Solve

(10 pts) Consider an 8 pole induction motor torque-speed curve of which is linearized near synchronous speed, in both motoring and generating regions. The linear curve slope is constant for all applied frequencies. The motor is operating with a **constant load torque** of 10 Nm at steady state while 40 Hz is applied, while the slip is 5 %.

- Calculate the synchronous speed (in rpm) for the above condition.
- Calculate the operating speed (in rpm) for the above condition.

- Draw the torque speed curve of the induction motor (only linear region) along with the load torque. Mark the operating point and synchronous speed.
- Suppose that the applied frequency is suddenly reduced to 45 Hz. Draw the new torque speed curve on the same graph. Suppose that the electrical time constant is zero. Show the new operating point **just after** the frequency reduction.
- Mark the new operating point at the new steady state and calculate the new operating speed. Notice that the load torque does not change.

**Part III: Think**

(10 pts) Propose a method to calculate the time taken from the old steady state operating point to the new one. Take the inertia seen by the motor as  $1 \text{ kg.m}^2$ . Use analytical expressions and explain your reasoning.