Closed book, closed notes portion.

True/False Questions (1 pt each)

___ 1. Piezoelectric accelerometers work by converting the force applied to a known mass \( a = F/m \) into a resistance change measured by a Wheatstone bridge.

___ 2. PWM stands for Pulse-Width-Modulation - a way to vary the speed of an electric motor.

___ 3. The speed of an AC motor depends only on input frequency and the number of poles.

___ 4. Potentiometers and LVDT’s are used to measure linear displacement.

___ 5. Accelerometers are frequently used to measure low frequency vibrations ( < 100 Hz).

___ 6. When used as a tachometer, a DC motor will produce a voltage that is proportional to the angular position.

Short answer questions - use the space provided for written answers.

7. [6] The setup below is used to measure angular velocity of a shaft. In a 0.80 second period, a total of 375 pulses are counted. What is the nominal angular velocity in RPM? What is the resolution of this measurement?

![Diagram of magnetic pickup and gear with pulses counted over time]
8. [10] Select and briefly justify the single best motor type from the list below for each of the following applications (cannot use same motor type twice, exactly 5 of the 6 motor types listed below should be selected and justified):

1. PSC AC motor
2. shaded pole AC motor
3. DC motor (w/brushes)
4. split phase AC motor
5. brushless DC motor
6. universal motor

a) antenna positioner on $25M satellite

b) multi-speed kitchen blender

c) tabletop single speed fan

d) electric wheelchair drive

e) conveyor belt at grocery store check-out line
   a) Determine the damped natural frequency for the system.
   b) If the 2nd order system consists of a spring and a mass, estimate the spring constant K if the mass weighs 33 lb.

![Plot of experimental data](image)

10. [26] A DC permanent magnet motor runs at 6710 RPM and develops 1.36 hp of output power when operated at an applied voltage of 150 volts and an armature current of 8.11 amps. Determine the following:
   - the motor’s efficiency at this operating point,
   - power dissipated in the windings at this operating point,
   - the motor’s armature resistance, $R_a$.
   - the motor’s theoretical torque constant, $k_a$.
   - the motor’s theoretical back-EMF constant, $k_b$. 

   Over
11. [26] Four strain gages are mounted (two on top, two on bottom) to a brass beam with a rectangular cross-section as shown. Note that the cantilever beam is loaded in bending.

a. Sketch the arrangement of the strain gages in the Wheatstone bridge. Arrange the gages such that a positive P (downwards) creates a positive output voltage, $E_o$. Clearly indicate both the input and output voltages on the sketch.

b. Determine the output voltage, $E_o$ from the Wheatstone bridge with the following nominal parameter values (dimensions given in figure):

Load, $P = 7.30$ lbf
Input voltage, $E_i = 12.7$ V
Gage Factor, $F = 2.10$
Material: $E_{brass} = 15.9 \times 10^6$ lbf/in$^2$