Test 2 2020 Questions

Mechatronics (McMaster University)

Name:_____ Student #:_____

MECHANICAL ENGINEERING 4H03

DAY CLASS — Dr. Gary Bone
Duration of Test: 50 minutes
Test #2 — March 3, 2020

This test paper includes 5 questions and 6 pages. Please ensure that your copy of the paper is complete.

SPECIAL INSTRUCTIONS:

- **Print your name and student number at the top of pages 1, 3 and 5.**
- **Show your work; include all relevant equations and calculation steps.**
- This is a closed-book test. Only the McMaster Standard Calculator (CASIO FX-991MS or FX-991MS PLUS), pens and pencils are permitted.
- Answer all questions neatly.
- All answers should be written in the spaces provided on this test paper only.
- Marks for each question are shown in the left hand margin. The test is out of 40.
- A list of equations will be handed out separately.

10 **1. a)** A load is to be moved at 2 m/s using a rack and pinion. If the motor speed is 1200 rpm, determine the pinion's required pitch radius.

Answer to a):

b) For the same rack and pinion, if a force of 400 N is required to move the load, and the rack and pinion's efficiency is 0.8, determine the required motor torque.

Answer to b):

c) Now, the load is to be moved at 0.5 m/s using a lead screw. If the screw has a lead of 0.005 m/rev, determine the required motor speed in rpm.

Answer to c):

d) For the same lead screw, if a force of 400 N is required to move the load and the screw's efficiency is 0.6, determine the required motor torque.

Answer to d):

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9 **2.** A single rod pneumatic cylinder will be used to move a mass horizontally in both directions at a speed of 0.2 m/s. The cylinder must overcome a friction force of 2000 N during its motion. The inertia force is relatively small and can be neglected. The rod's cross-sectional area is 9×10^{-4} m^2, the supply pressure is 6×10^5 Pa gauge and the air temperature is 25 °C. If a pressure drop of 4×10^4 Pa across the valve is desired, determine:

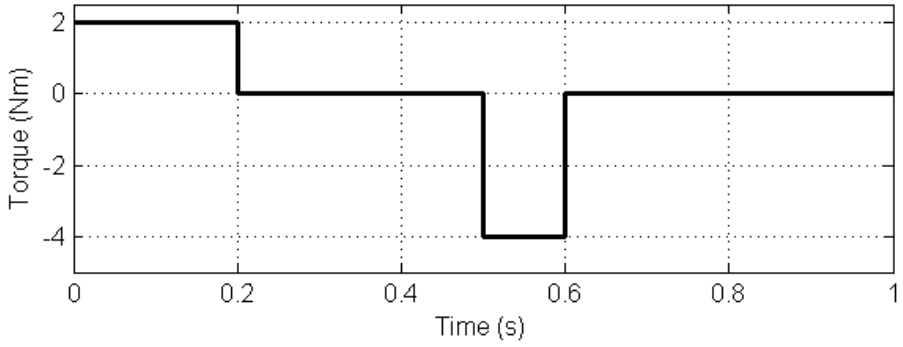
a) The minimum bore cross-sectional area required.

b) The minimum valve flow coefficient required.

Assume that the pressure drop across the valve is the same for the return flow as for the intake flow and that the air is returned to the atmosphere.

9 **3.** A motion cycle requires a motor to produce the torque profile shown below. The ambient temperature is 30 °C and the motor's parameters are given in the table. Determine the temperature the motor windings will reach if the motion cycle is repeated continuously.

Torque constant (Nm/A)	0.4
Resistance at max. temp. (ohm)	1.2
Total thermal resistance (ºC/W)	2



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6 **4.** A linear actuator consisting of a motor, gearbox and ball screw moves a load vertically. A positive motor velocity moves the load upwards. The screw's moment of inertia is 1.5×10^{-4} kgm^2, the motor's moment of inertia is 3×10^{-5} kgm^2 and the gear ratio is 2.5. The screw's lead is 0.002 m/rev. If the load has a mass of 500 kg and is subject to a 800 N friction force, **determine the motor torque required for the load to accelerate upwards at 1.2 m/s^2**. The friction of the gears and ball screw can be neglected.

6 **5. <u>Based on the material covered in this course</u>**, answer the following questions in the spaces provided:

a) A _____ consists of a coil and a soft iron core.

b) When half stepping mode is used instead of full stepping, the advantage is the _____ is halved, and the disadvantage is the _____ is reduced.

c) Inertia matching maximizes the _____ and _____.

d) List two advantages and two disadvantages of piezoelectric actuators.

<u>Two Advantages:</u> _____

<u>Two Disadvantages</u>: _____

e) List two advantages and two disadvantages of ultrasonic motors.

<u>Two Advantages:</u> _____

<u>Two Disadvantages</u>: _____

END OF TEST