

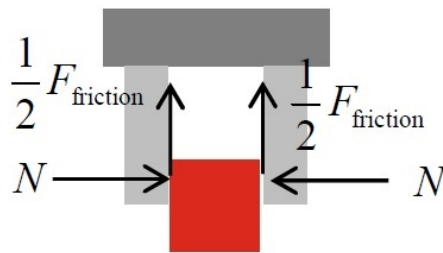
Advanced Mechatronics System Design – MANU 2451

Final Exam (Semester 1, Year 2016)

Question 1 (2 Marks)

Assume you have a two-finger flat-surfaced gripper as shown in the figure below. You are looking at it from the side view, i.e. the dark grey rectangle is on top and the red object is below. The gripping force, $N = 20\text{N}$, and the coefficient of friction between the finger and the object is 0.1. Assume gravitational acceleration as $g = 10\text{ ms}^{-2}$.

If the gripper accelerates upwards with an acceleration of 20 ms^{-2} , what is the maximum mass of the object which the gripper can grip without sliding? Show your work out, not just the final answer. (2 Marks)



Space for answer:

Question 2 (10 Marks)

- (a) Assume you have two gears, both with module 3. The driving gear (first gear) has 10 teeth, whereas the driven gear (second gear) has a diameter of 150mm. What is the gear ratio of this pair of gear? Show your work out, not just the final answer. (4 Marks)
- (b) If the driving gear rotates at 100 RPM, what is the angular velocity of the driven gear in unit radian/second? Show your work out, not just the final answer. (2 Marks)
- (c) The driving gear is actuated by a DC motor, whereas the driven gear is subject to a load torque of 9Nm. If the gear efficiency is 90%, what is the minimum torque which the DC motor should have, to ensure that the load can be moved by the gear-system? Show your work out, not just the final answer. (4 Marks)

Space for answer:

Question 3 (8 Marks)

- (a) You have an IR Range Sensor, and you started off by calibrating the sensor, by measuring the sensor signal (in voltage) against known distances. Here is a table of your measurements:

| Distance (R) in mm | Sensor signal (V) in volt |
|--------------------|---------------------------|
| 10 | 0.222222 |
| 30 | 0.068966 |
| 50 | 0.040816 |
| 70 | 0.028986 |

Derive a linear relationship between the distance (R) and the sensor signal (V). Show your work out, not just the final answer. (6 Marks)

- (b) After calibration, you use the IR Range Sensor to measure distance to an object. If the sensor signal is 0.1V, what is the distance to the object? Show your work out, not just the final answer. (2 Marks)

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Question 4 (6 Marks)

An encoder has 180 pulses per revolution.

- (a) How many degrees did the encoder shaft turn, if 20 rising edges at Channel A have been detected? Show your work out, not just the final answer (2 Marks).
- (b) Explain how you can determine the direction of rotation (clockwise or anticlockwise), if you use the encoder in the x1 logic mode. (1 Marks)
- (c) Explain how you can determine the direction of rotation (clockwise or anticlockwise), if you use the encoder in the x4 logic mode. (3 Marks)

Space for answer:

Question 5 (4 Marks)

- (a) What is the main reason to use a stepper motor? (1 Mark)
- (b) A stepper motor has 4 coils (A, B, A-bar and B-bar). The rotor is made of permanent magnet with one North pole and one South pole. Explain how you can achieve a resolution of 45 degrees for the rotor rotation, without consideration of the torque ripple problem. (2 Marks)
- (c) How can the torque ripple caused by the method explained in your answer to (b) be minimized? (1 Mark)

Space for answer:

Question 6 (2 Marks)

A Piezo bimorph actuator has a length of 20mm and a thickness of 0.65mm. The strain coefficient normal to polarization is -0.2nm/V . How much is the linear displacement at the tip of the actuator, if it is given a voltage of 50V? Show your work out, not just the final answer (2 Marks)

Space for answer:

Question 7 (8 Marks)

- (a) Sketch out a Series DC motor. (2 Marks)
- (b) Name one advantage of a Series DC motor. (1 Mark)
- (c) In your own words, explain why a Series DC motor can also be driven by an alternating current source. You may add some sketches to aid your explanation (5 Marks)

Space for answer:

