Practice Problem 1:

It is Halloween and you have to study for your midterm exam and do not want to be bothered by trick-or-treaters coming to your door. So, you built a robot that opens the door when the trick-or-treaters come in and dolls out candy to the pesty visitors. On each visit the robot spews out one candy with probability 0.6, two candies with probability 0.3 or three with probability 0.1.

To signal when it is time to refill the candy compartment, your robot uses a sensor that estimates the number of candy left. It can estimate an accurate count with probability 0.6 or it can be off by one in either direction with probability 0.2.

You fill up the compartment with 50 candies. After the first visit, the sensor measured 48. After the second visit, the sensor measured 48 again. Calculate the belief of the number of candy left in the compartment after the first and the second visit.

Practice Problem 2:

The motor is driving a pinion-and-rack mechanism shown in the figure. The system has three sensors: shaft encoder that measures the angular velocity of the pinion gear, potentiometer that measures the voltage proportional to the position of the pinion gear and a current sensor that measures the current through the motor. The motor dynamics is that of a DC motor and the payload that the pinion gear is driving generates a constant load torque on the motor shaft.

Derive the model and based on the result state which filter you would use to estimate the position of the pinion gear. Derive all equations necessary to implement the filter.

Assume the following system parameters: Torque constant is K=0.01 Nm/A. Rotor inertia is J=0.01 kgm^2. Friction constant is b=0.01 Nms. Armature resistance is 1 ohm and the inductance is 0.5 H. The radius of the pinion gear is 5cm and the height of the rack is 10m. The potentiometer reference voltage is 10 V. The covariance is diagonal and the variance for each state vector component is 0.02.

Assume that the load torque is 1Nm and that the motor driving voltage is 10 V. The variance of both is 0.01 and that at present time the motor shaft angular velocity is 11 rad/s, the pinion position is 2, and the current through the motor is 10A. Sensors are measuring 11.1 rad/s, 1.98m, and 9.96A all with variance 0.1. All measurements and inputs are independent. Calculate the updated state assuming sample rate of 10 Hz.