1. **Accelerometers and Gyroscopes**

Visit the SparkFun robotics “Accelerometer, Gyro, and IMU Buying Guide” at [https://www.sparkfun.com/pages/accl_gyro_guide](https://www.sparkfun.com/pages/accl_gyro_guide). Then answer the questions below. Please typeset your answers (although you can hand-draw the plot for e if you like).

a. Explain the tradeoff between sensing range and precision (note that this tradeoff is endemic to all sensors, not just accelerometers and gyroscopes). How does this relate to our discussion of A/D converters in class?

b. What’s the difference between a gyroscope and an accelerometer? What are they good for? Which one can tell you which way is down, and why?

c. Sketch a plot of the output of a single-axis accelerometer (aligned vertically) as it takes a trip up the Hicks elevator, starting at zero velocity in the basement, and ending at zero velocity on the third floor, with a long constant-velocity segment in the middle. Your plot should have time on the $x$-axis and sensor output on the $y$ axis. *Please consider the following when sketching your plot:*

   - Remember, the sensor will *not* read zero when stationary!
   - Think carefully about whether the sensor reading increases or decreases at the start of the ascent.
   - No real-world physical system can instantaneously change its velocity.

d. It would be really useful to have a sensor that directly measures linear velocity without observing any outside references. Explain why this is more or less impossible. How could you try to “fake” such a sensor using an accelerometer? (Consider the example above.)
2. Specifying a motor

To specify a motor for a robot, it’s a good idea to estimate the peak power that will be required. Assume that the Turtlebot pictured below weighs 5 kg, and that we want it to be able to climb a 30° incline at a velocity of 0.75 m/s.

![Diagram of forces](image)

The force applied by the robot, $F_{app}$, must be enough to lift the robot’s weight up the slope against gravity, and to oppose the force of friction:

$$F_{app} = F_f + F_w$$

In the computations below, make sure you use the appropriate units, and show your work.

a. Start with $F_w$, the force required to counter gravity. It should be equal to the projection of the gravity vector onto the direction of motion. Compute $F_w$ in Newtons.

b. Next, consider $F_f$, the force of friction, which is the product of the coefficient of friction $\mu$ (conservatively assumed to be 0.3) and the projection of the force of gravity perpendicular to the surface, $F_N$. Compute $F_f$ in Newtons.

c. Now you should have $F_{app}$, the magnitude of the applied force. Power is force times velocity. What is the mechanical power, in Watts, required to get the robot up the hill at the desired speed?