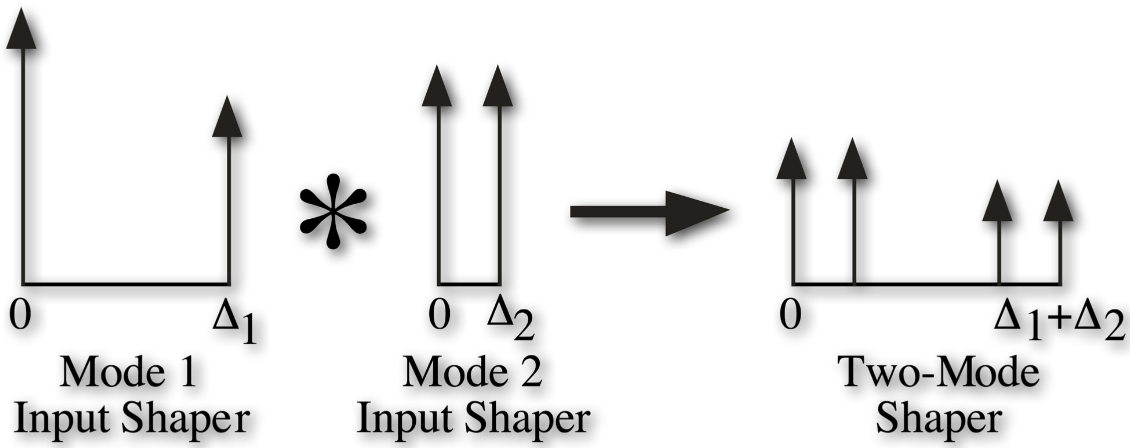
Multi-Mode Input Shapers

If we know that there are higher modes, we can eliminate them too

1) design a shaper for each ω_i

2) convolve the shapers

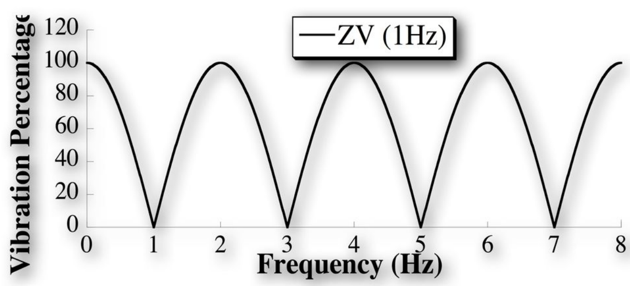


3) Use the total two-mode shaper to drive the system

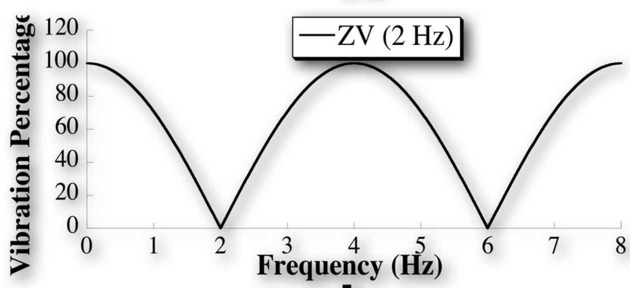
Q: Why does this work?

The sensitivity curves combine too.

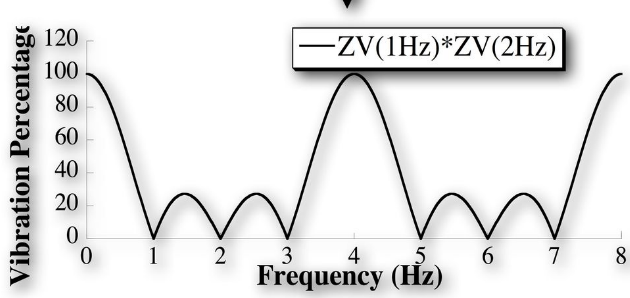
ZV Shaper for 1 Hz



ZV Shaper for 2 Hz



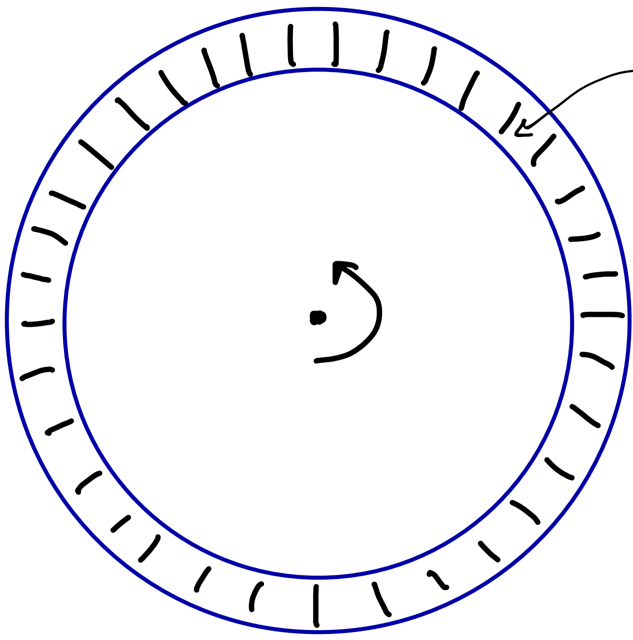
ZV Shaper for 1 Hz and 2 Hz



Sensors and Sensing

Common sensors used in robotics include:

* Potentiometers
* Encoders
  - Rotary - sense either relative or absolute rotary motion
  - Linear - sense linear motion



slots.... basically, shine light in one side and sense light on the other. The number of light pulses you "see" tell you how far you've moved.

This simple one would only give relative position.

It's a relative encoder

With "fancier" slits you can get absolute position → absolute encoder

Linear encoders work similarly but in straight lines.

Return to code is usually encoder pulse (gives number of counts)

Q: How can we use this for positioning?

property of the encoder — counts per revolution

on wheels:

$$\frac{\text{wheel circumference}}{\text{counts per rev.}} = \text{distance per count}$$

on joints:

$$\frac{360^\circ}{\text{counts per rev}} = \text{degree per count}$$

Q: What are some potential problems?

- for wheels → wheel motion doesn't necessarily mean you're moving
- finite accuracy - need much higher resolution than you might think

  a 360 count encoder has ±1 degree of error... that compounds over time!!!

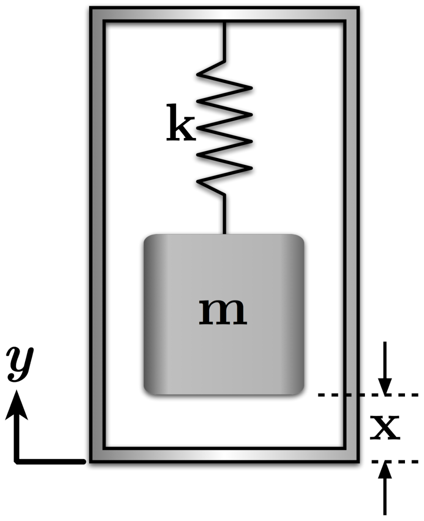
Gyroscopes

measure angular velocity

not affected by gravity

A good compliment to...

Accelerometers



we measure x (usually via a piezoelectric material) to get some info on $\ddot{y}$

let ω = excitation freq and ω_n is natural freq. of the sensor.

We can find that if $\omega \ll \omega_n$, then

$$\ddot{y}(t) \approx -\omega_n^2 x(t)$$

To get the accel of y, measure x and mult. by $-\omega_n^2$

Because we want $\omega \ll \omega_n$ → want high ω_n → high k, low m → small sensor size.

Q: What else could we sense with an accelerometer?

tilt... due to effects of accel due to gravity

Q: Can we use accel. to get reliable position data?

yes, but it's not simple (we can't just integrate twice)

(see slides)

Q: How can we get accurate position and accel?

some combination of sensors

Inertial Measurement Units (IMUs)

essentially combine gyro + accel in one package } still often need other sensors to get precise data

Other common sensors:

GPS - Global Positioning System

Satellite based positioning system

Q: Problems?

- often not accurate enough alone (error is typically on the order of m)
- reception problems (need a "lock" with 4+ satellites)
  - urban environment can cause problems
  - can't use indoors

Laser-based Rangefinders or Scanners

have really downsized recently, but still expensive (demo'd in lecture)

can also be computationally expensive.

IR or Sonar-based Distance Sensors

nearly identical theory of operation - bounce a wave off things, use time of return to calculate distance