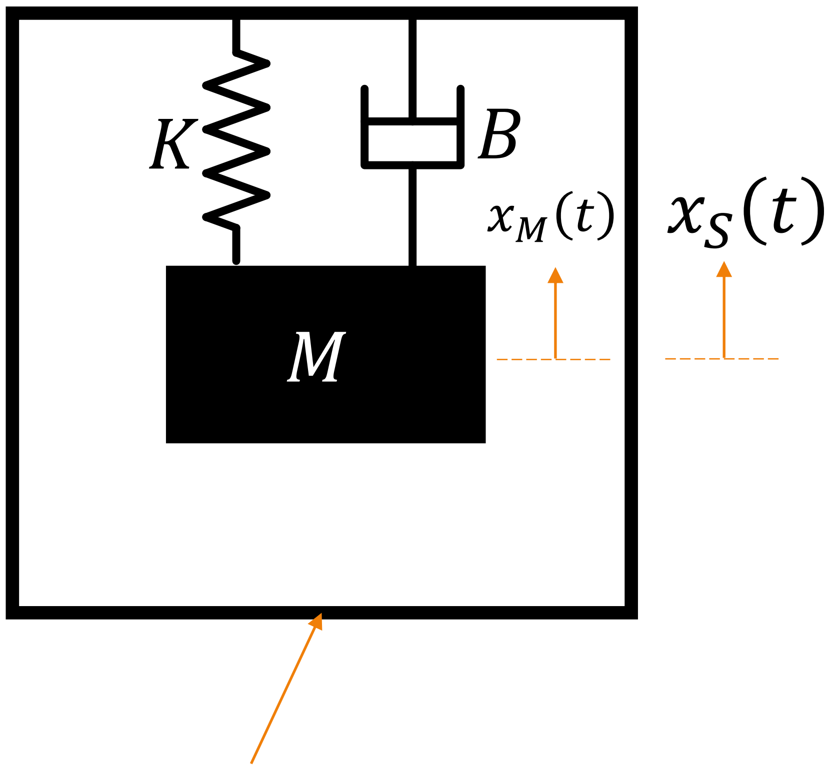
Transducers & Instrumentation

Module 03 - 02

Measuring Movements

Accelerometers



Accelerometer

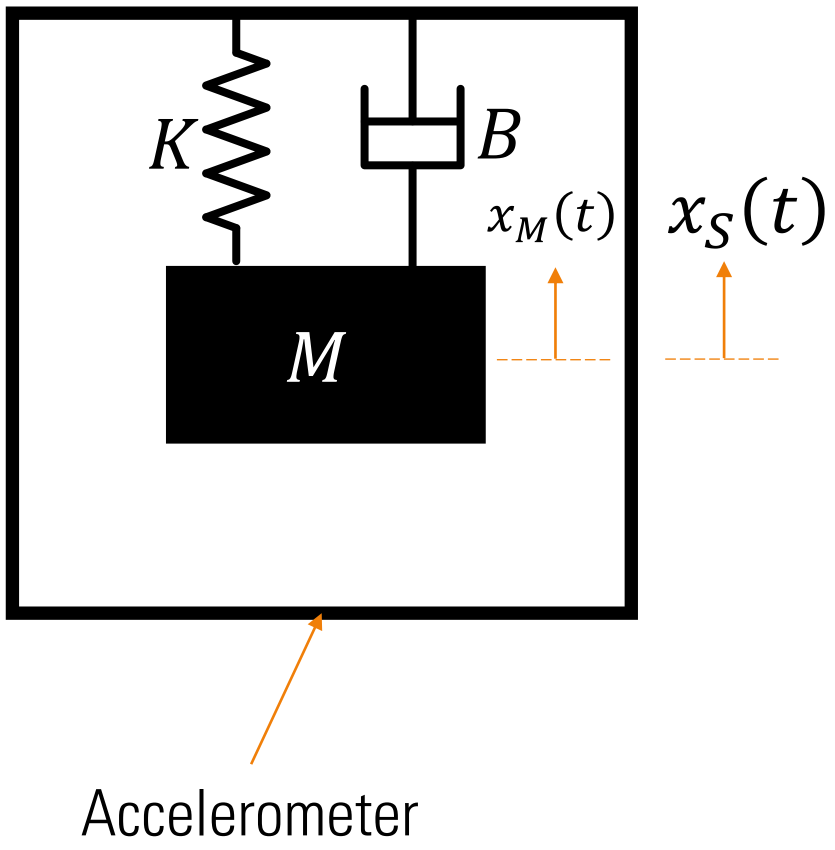
$x_S(t)$ is the movement of the accelerometer, and $\ddot{x}_S(t)$ is its acceleration.

Acceleration of the accelerometer results in movements of the mass M, $x_M(t)$.

We are interested in the relative movement of the mass within the accelerometer,

$$y(t) = x_S(t) - x_M(t)$$

Accelerometers



$$M\ddot{x}_M(t) = K \cdot \left(x_S(t) - x_M(t)\right) + B \cdot \left(\dot{x}_S(t) - \dot{x}_M(t)\right)$$

$$Ms^2 X_M(s) = K \cdot \left(X_S(s) - X_M(s)\right) + sB \cdot \left(X_S(s) - X_M(s)\right)$$

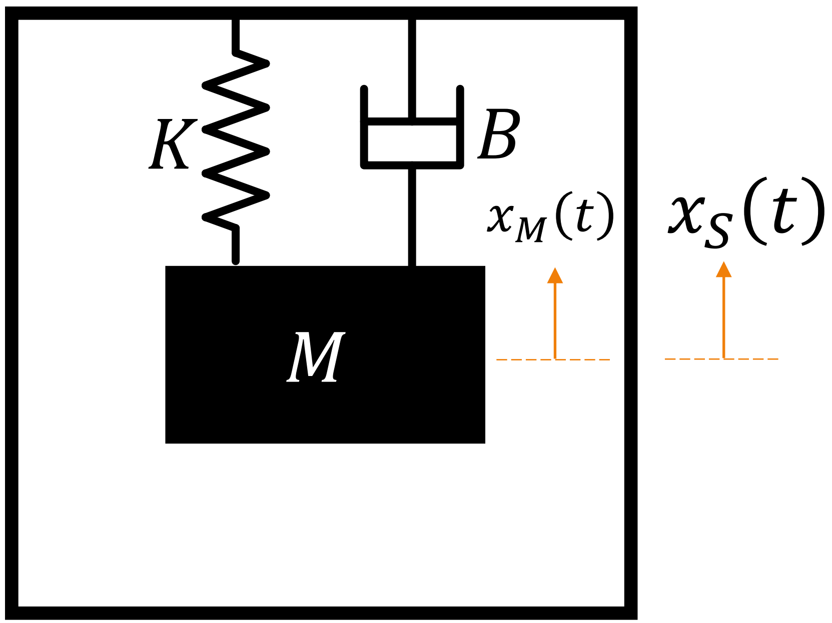
$$X_M(s) = \frac{sB + K}{s^2M + sB + K} X_S(s)$$

$$\downarrow$$

$$Y(s) = X_S(s) - X_M(s) = \frac{s^2M}{s^2M + sB + K} X_S(s)$$

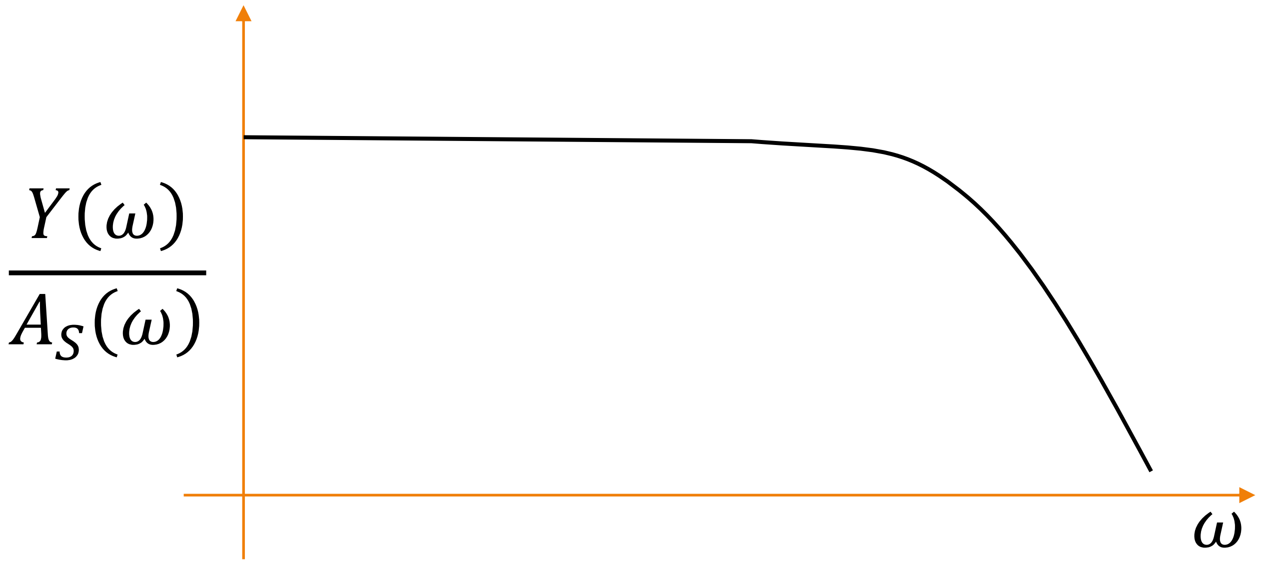
$$Y(s) = \frac{M}{s^2M + sB + K} A_S(s)$$

Accelerometers

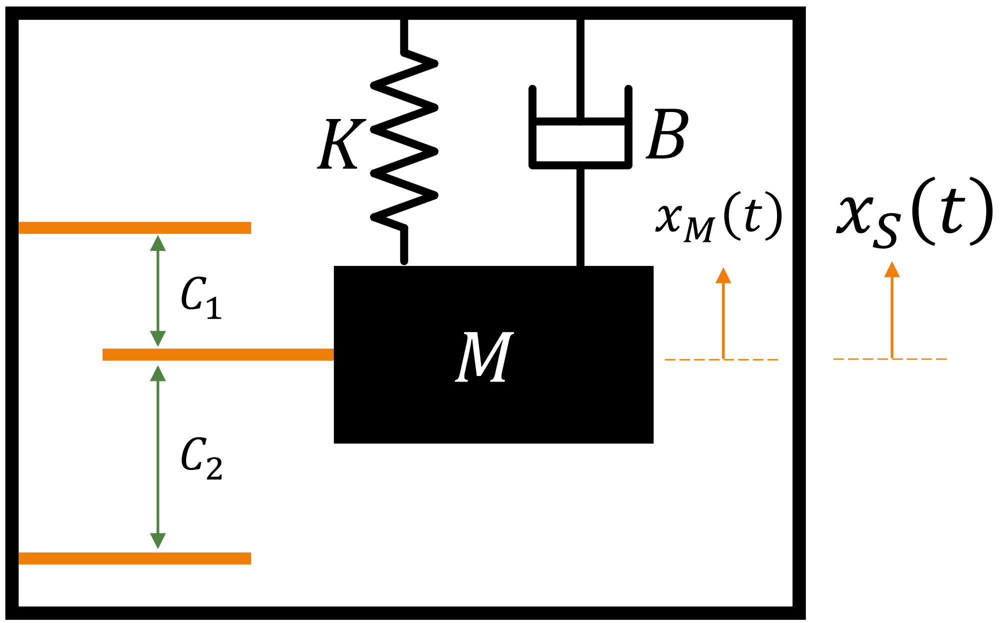


$$Y(s) = \frac{1}{s^2 + s\frac{B}{M} + \frac{K}{M}} A_S(s)$$

Natural Frequency $\omega_n = \sqrt{\frac{K}{M}}$ Static Sensitivity $= \frac{M}{K}$



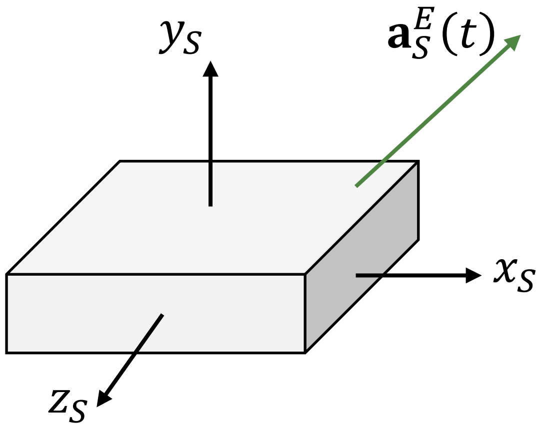
Accelerometers



$$Y(s) = \frac{1}{s^2 + s\frac{B}{M} + \frac{K}{M}} A_S(s)$$

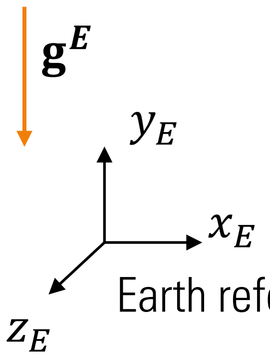
Capacitive sensing mechanisms for $y(t)$.

Multi-axis Accelerometers



Signal measured by the accelerometer will:

1) Contain acceleration due to gravity, and
2) Depend on the orientation of the accelerometer with respect to an inertial reference frame of interest.

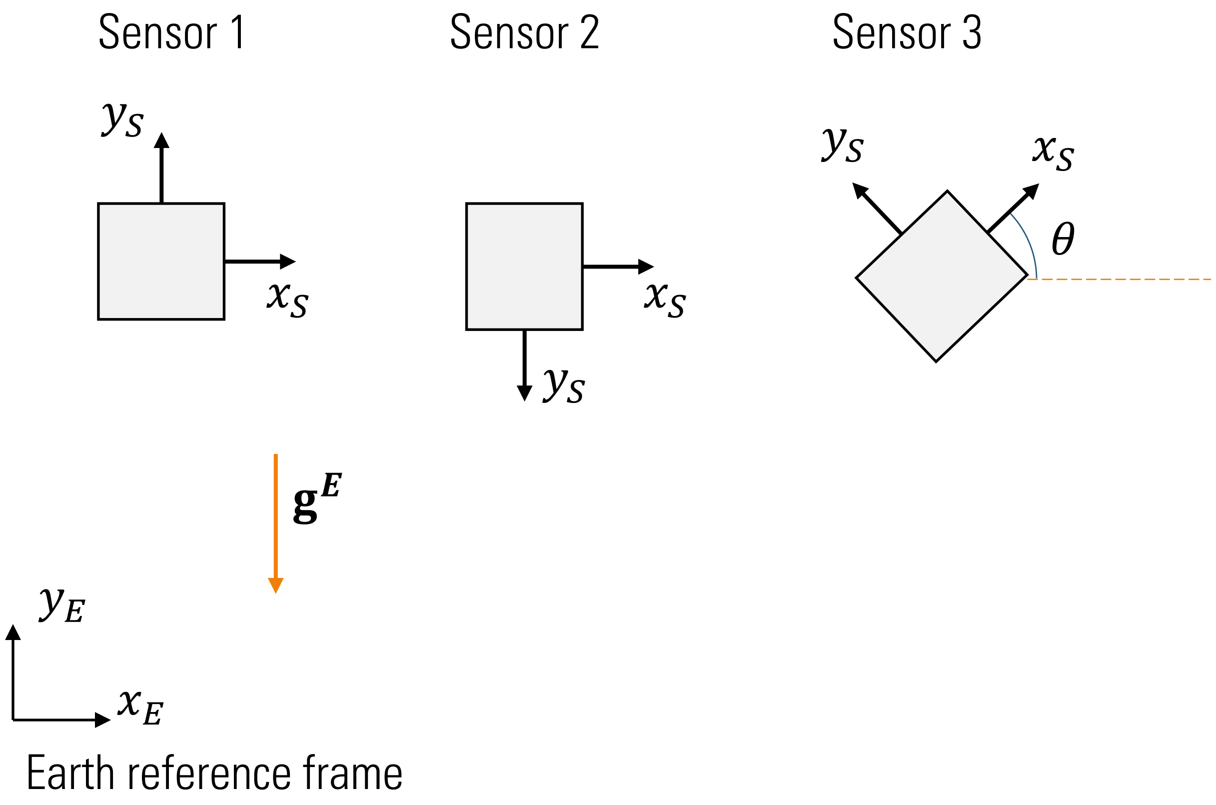


Earth reference frame

$$\mathbf{a}_S^S(t) = \mathbf{R}_E^S(t) \cdot \left(\mathbf{a}_S^E(t) - g^E\right)$$

Two-axis Accelerometers

$$\mathbf{g}^E = \begin{bmatrix} 0 \\ -9.81 \end{bmatrix} ms^{-2}$$

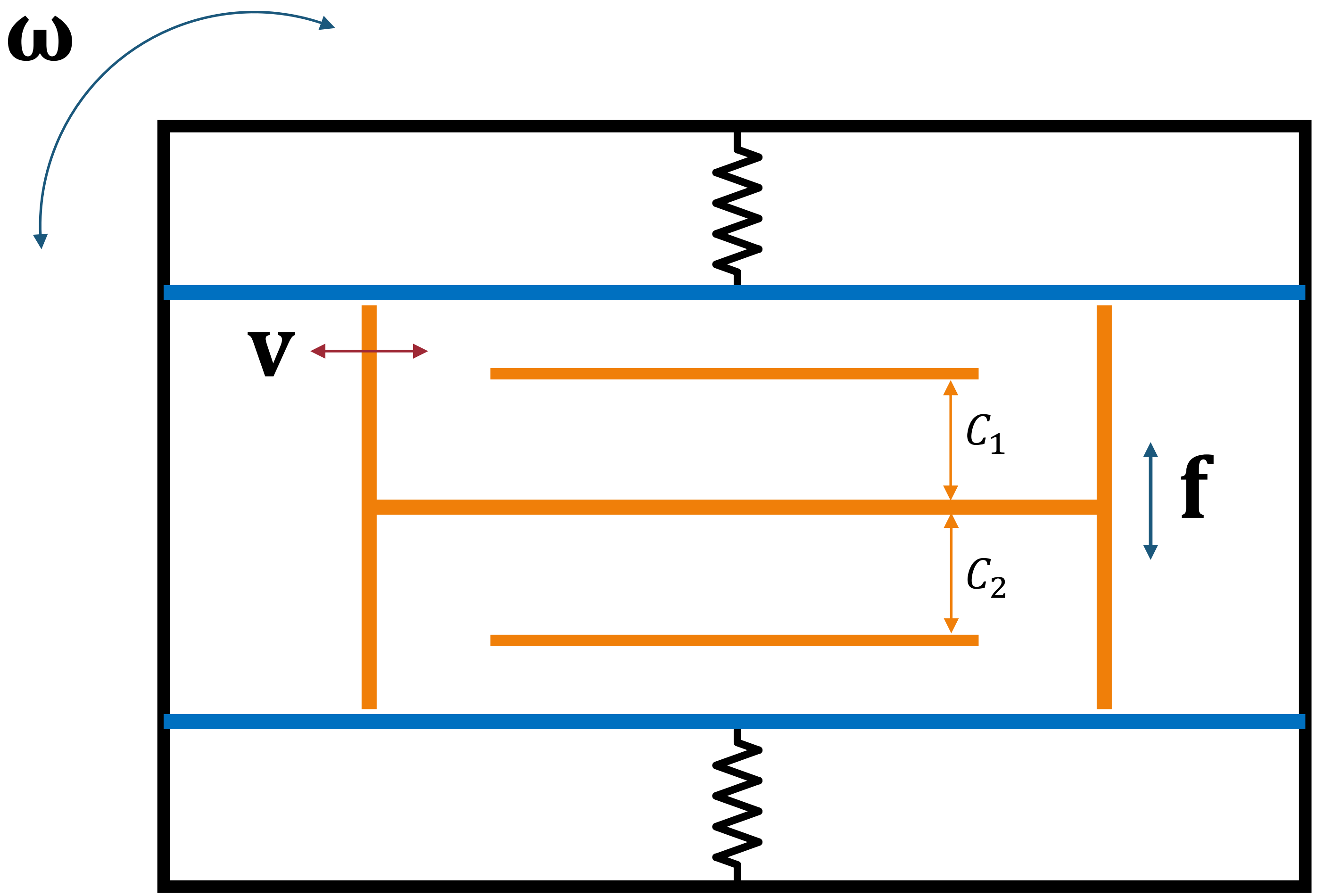


Sensor 1 $\mathbf{a}_S^S =$

Sensor 2 $\mathbf{a}_S^S =$

Sensor 3 $\mathbf{a}_S^S =$

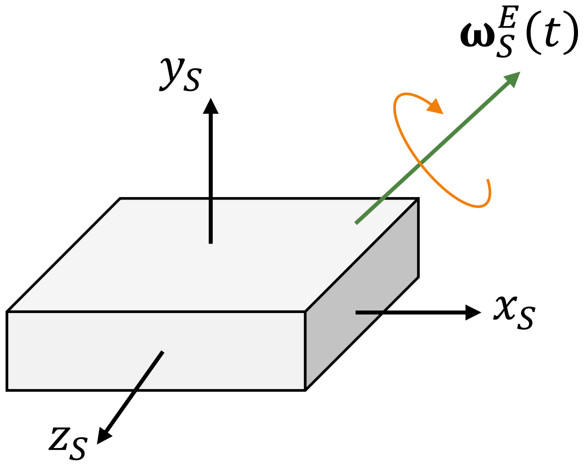
Gyroscopes

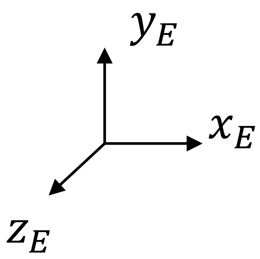


C_1 and C_2 are determined by the Coriolis force.

$\mathbf{v}$ is known, which can be used to compute $\boldsymbol{\omega}$

Multi-axis Gyroscopes





$$\boldsymbol{\omega}_S^S(t) = \mathbf{R}_E^S(t) \cdot \boldsymbol{\omega}_S^E(t)$$