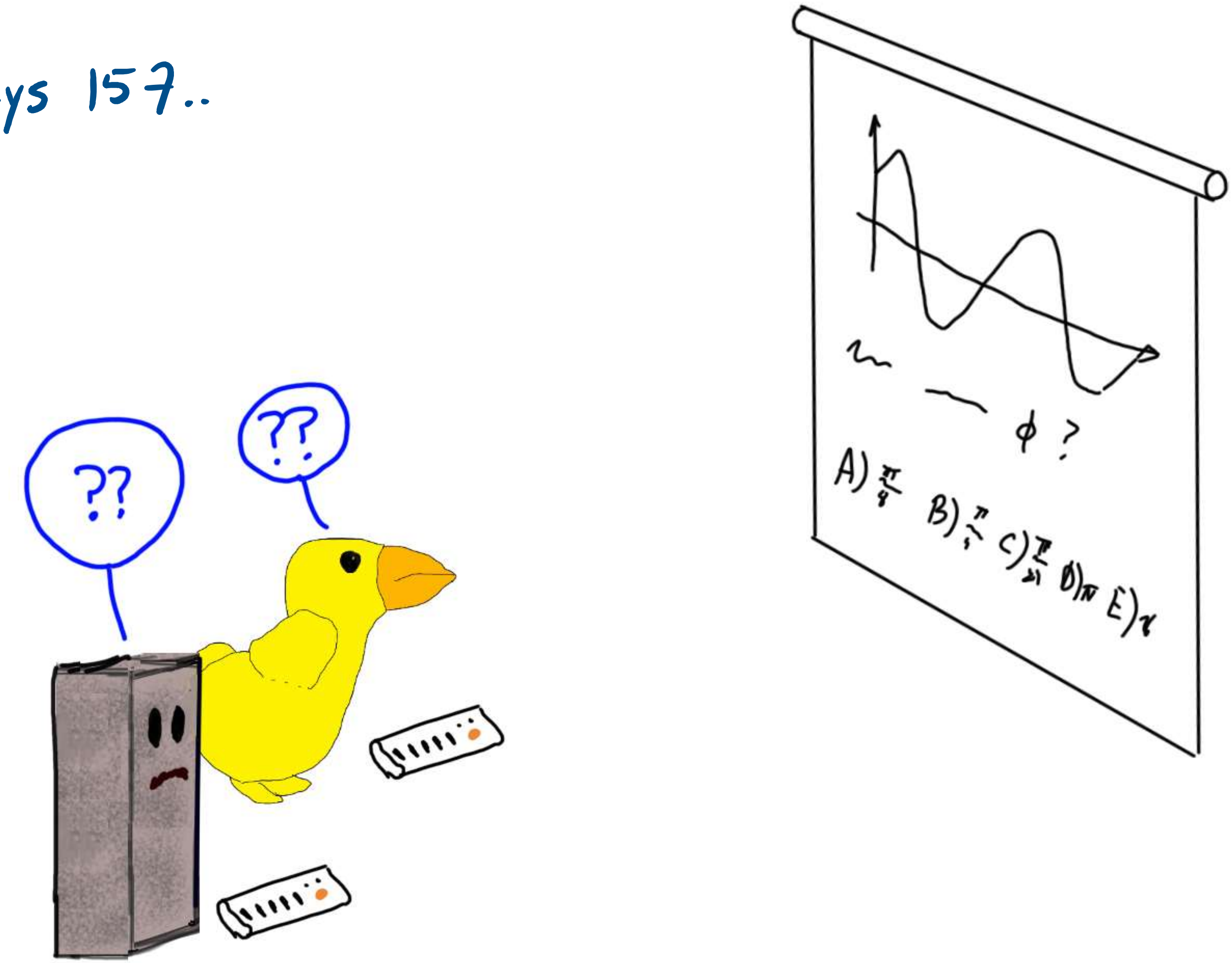
Last time in Phys 157..



Simple Harmonic Motion

$$x(t) = A\cos(\omega t + \phi)$$

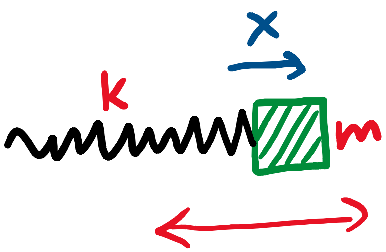
satisfies $\frac{d^2x}{dt^2} = -\omega^2 x$

$\frac{k}{m}$

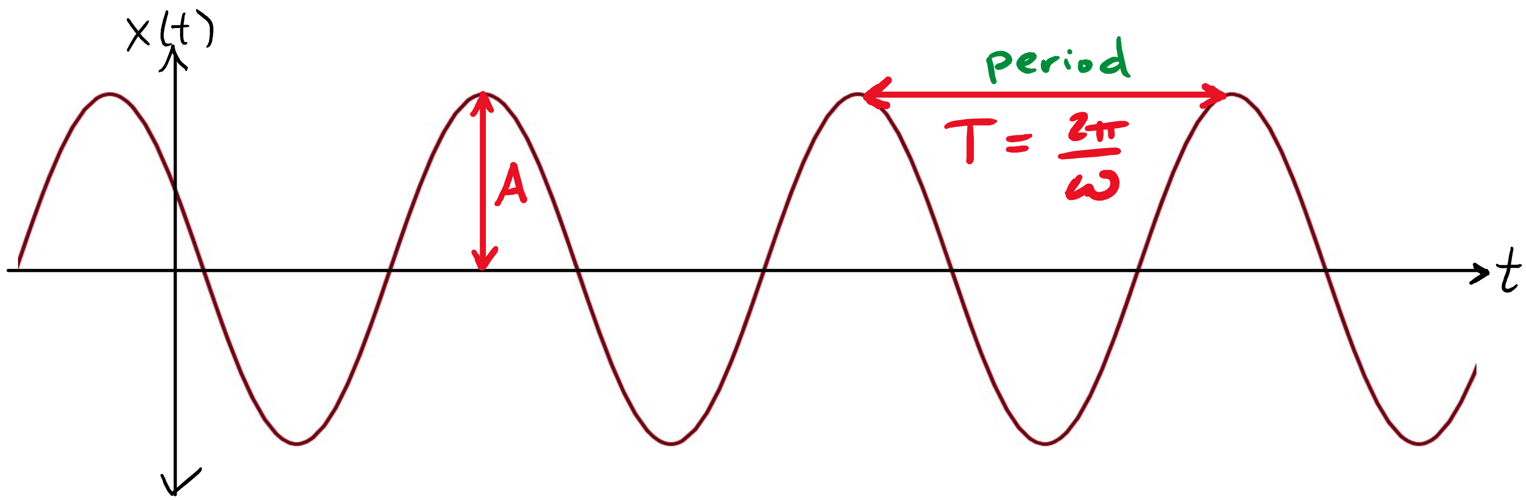
Amplitude

angular frequency

phase



$$\omega = \sqrt{\frac{k}{m}}$$



$\phi = \pm 2\pi \frac{t_{max}}{T}$ $\omega = \sqrt{\frac{k}{m}}$ $x(t) = A\cos(\omega t + \phi)$ $\omega = \frac{2\pi}{T}$

Approximately what is the spring constant of the spring in the simulation?

A) 1 N/m

B) 2 N/m

C) 4 N/m

D) 8N/m

E)16N/m

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A) 1 N/m B) 2 N/m C) 4 N/m

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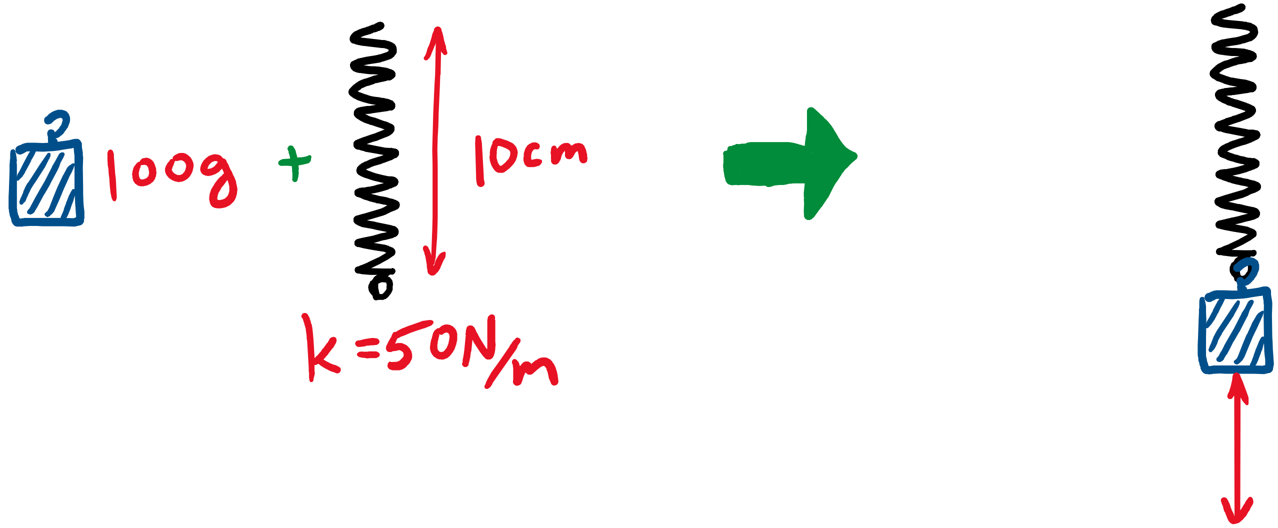
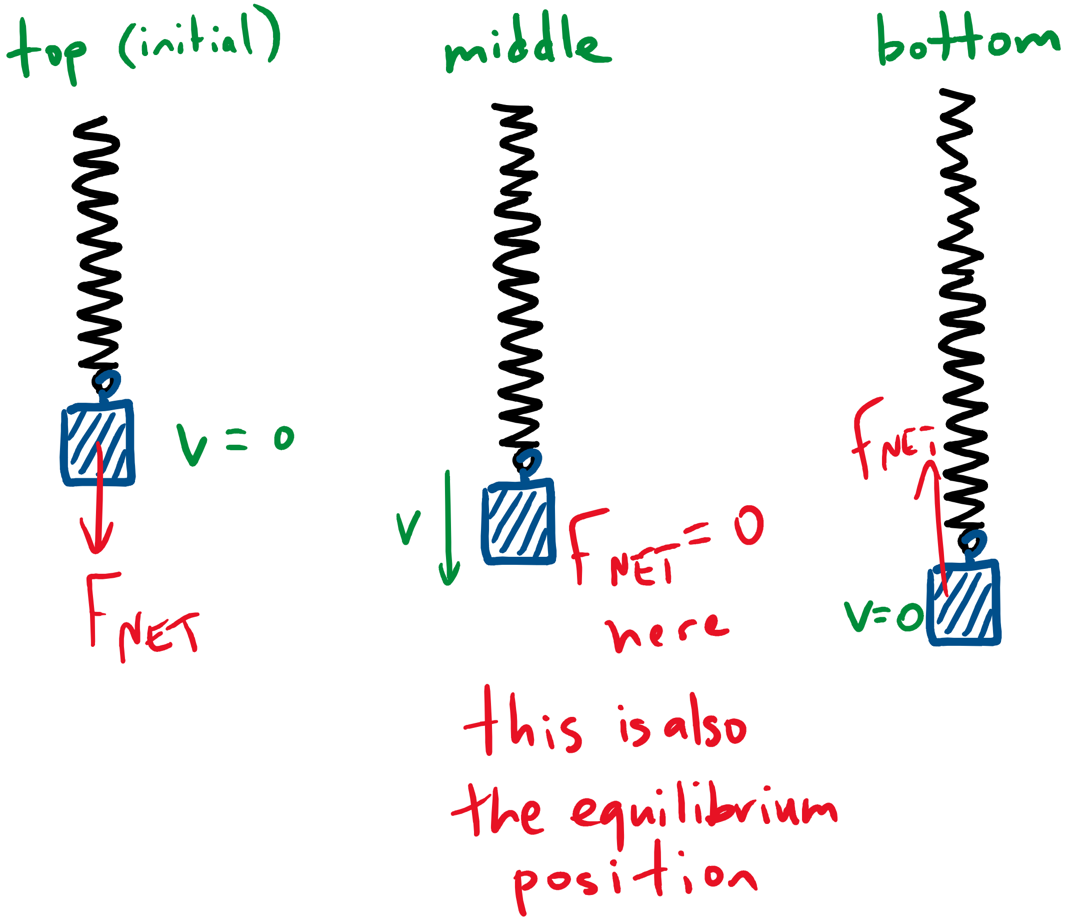
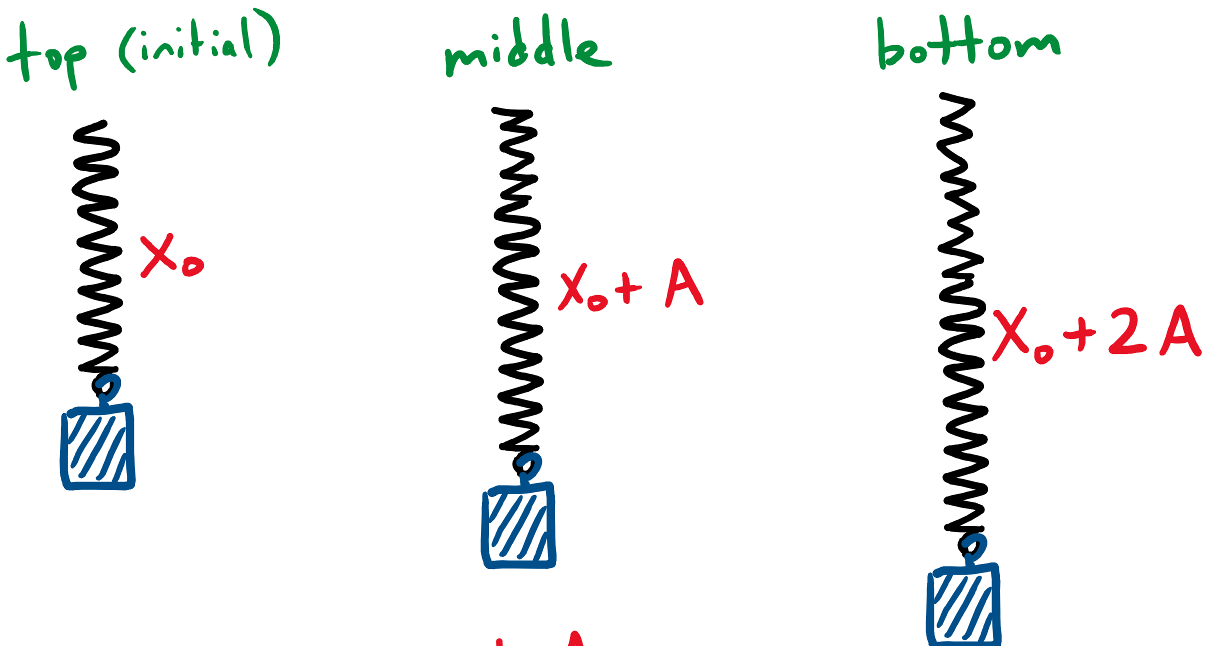
have: $T = 1s$ so $\omega = \frac{2\pi}{T} \approx 6.28\ s^{-1}$

Using $\omega = \sqrt{\frac{k}{m}}$ have: $k = m\omega^2 = 0.1 \times (6.28)^2\ N/m \approx 4\ N/m$



Discussion question: A 10cm long spring has a spring constant of 20 N/m. If we attach a 100g weight to the spring and release it, what will be the amplitude of the resulting oscillation?


top (initial)
v = 0
F NET
middle
v
F NET = 0
here
this is also
the equilibrium
position
bottom
F NET
v=0



Middle position is equilibrium position, so $F_{NET} = mg - kA = 0$ here.

$$A = \frac{mg}{k} = \frac{1\,N}{50\,N/m} = 2\,cm$$

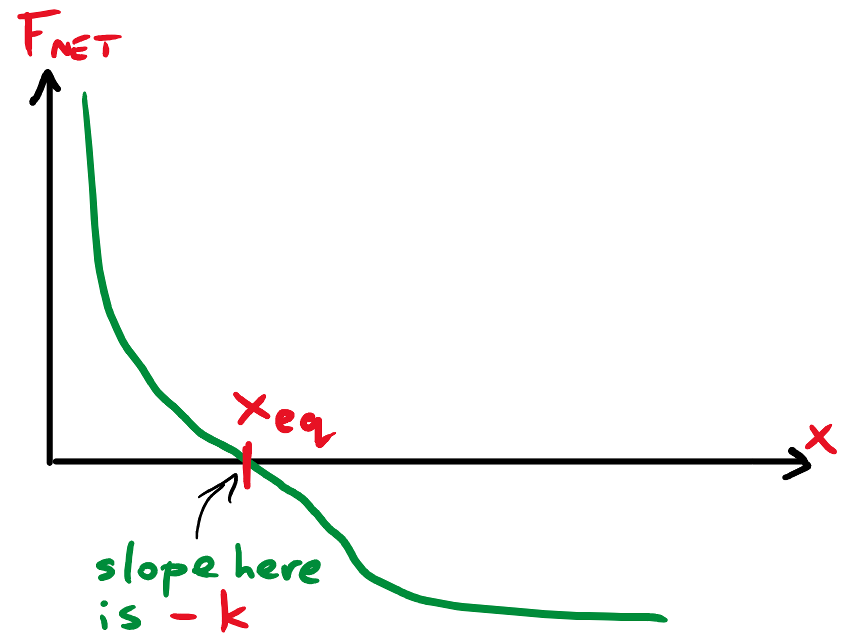
How to find ω in examples:

① Find F_{NET} as a function of position x

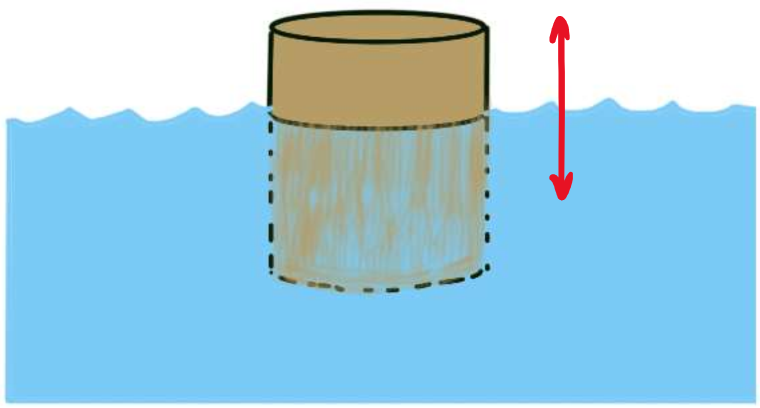
② Find equilibrium value x_{eq} by solving $F_{NET}(x_{eq}) = 0$.

③ $-k$ is $F'_{NET}(x_{eq})$, the slope at x_{eq}.

④ Then $\omega = \sqrt{\frac{k}{m}}$



Example: bobbing

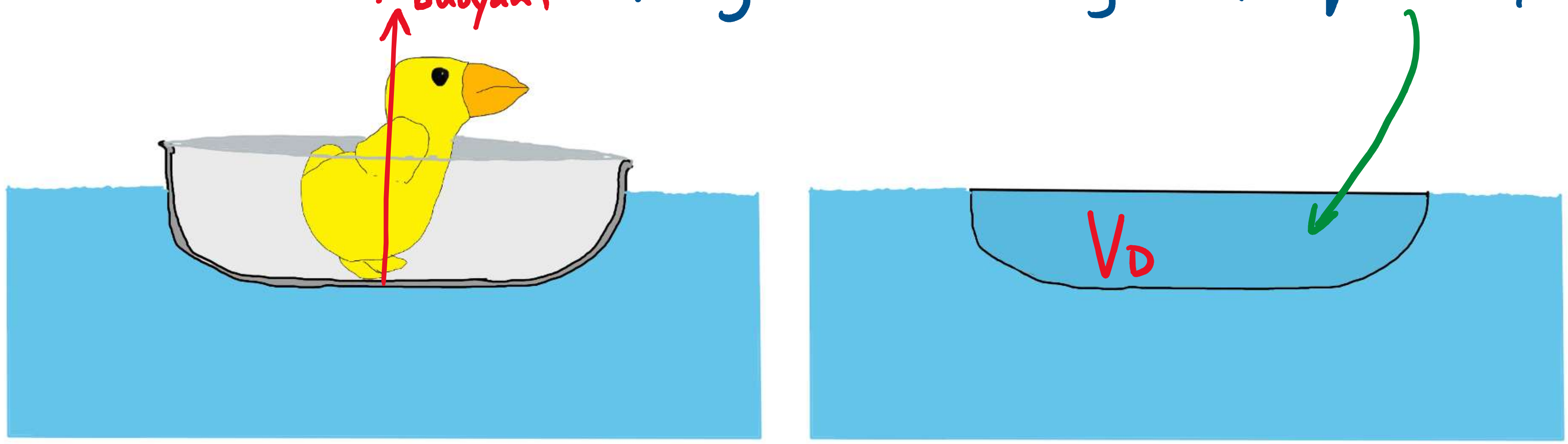


Is it SHM?

What does the frequency depend on?

The buoyant force: net effect of water+air pressure

$F_{buoyant}$: magnitude is weight of liquid displaced

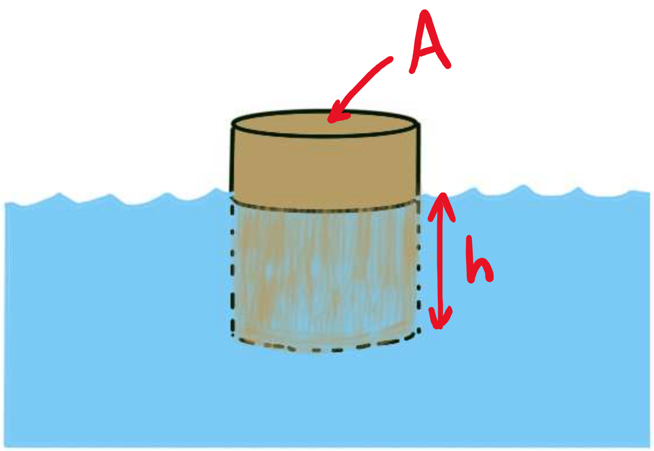


$$|F_{buoyant}| = \overbrace{V_D \cdot \rho_{liquid}}^{\text{mass of liquid}} \cdot g$$

volume

density

Example: bobbing



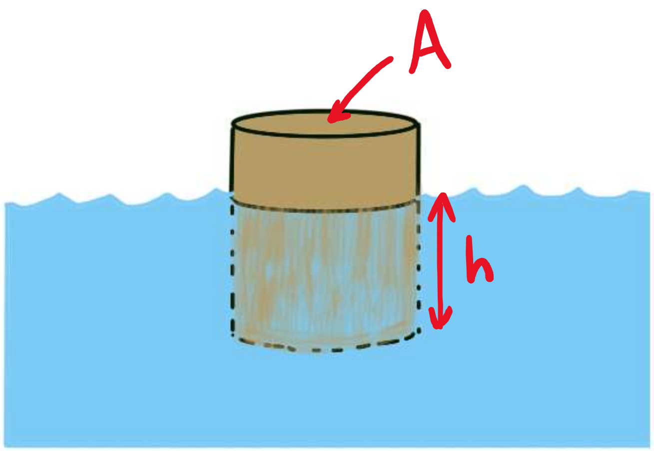
A cylindrical object of mass M and cross-sectional area A is placed in some water.

a) Draw a free body diagram for the object showing the vertical forces.

b) Calculate the magnitude of the net downwards force on the object as a function of the depth h that the object is in the water.

Answer in terms of h, A, M, g, and ρ_{water}

Example: bobbing



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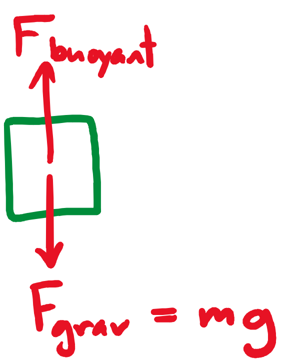
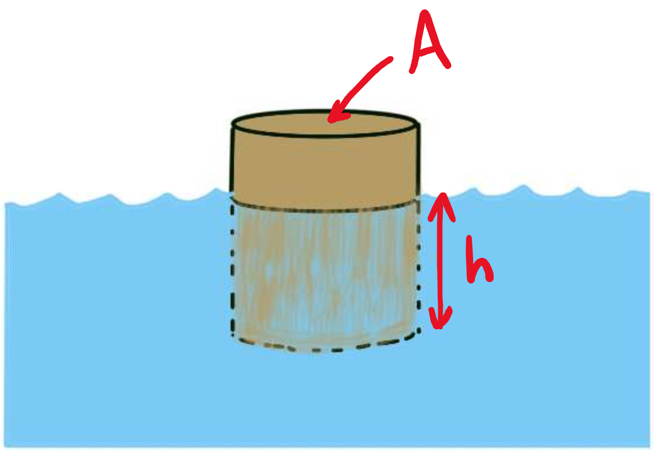


$$F_{buoyant} = g \cdot (\text{mass of water displaced})$$
$$= g \times \rho_w \times A \times h$$

$$F_{NET} = mg - g\rho A h$$

Example: bobbing



A cylindrical object of mass M and cross-sectional area A is placed in some water.

c) Graph the downward force as a function of h, for positive values of h, assuming the object floats.

d) What is the oscillation frequency in terms of h, A, M, g, and ρ_{water}?

Example: bobbing

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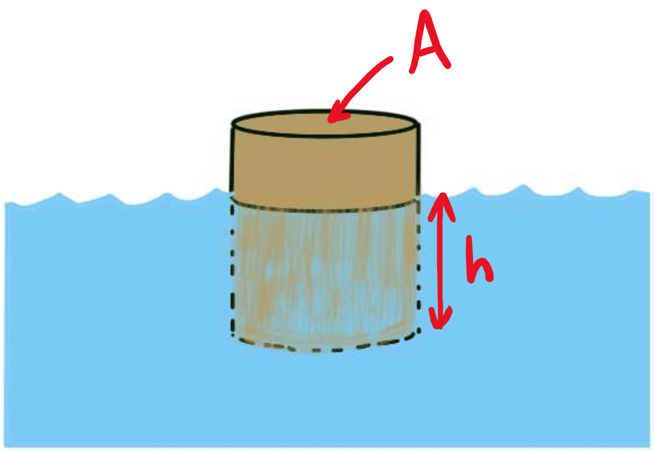

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$$F_{NET} = mg - g\rho A h$$

slope is $-g\rho A$: this is $-k$

$$\omega = \sqrt{\frac{k}{M}} = \sqrt{\frac{g\rho A}{M}}$$

smaller freq for larger M, smaller A