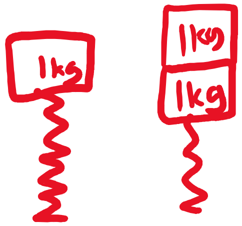
A 1 kg mass sits on a spring with k=1000N/m. If we add another 1kg mass on top, the amount by which the equilibrium position changes is about:

A) 1cm
B) 2cm
C) 10cm
D) 1m
E) It can’t be determined without knowing the unstretched length of the spring.



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C) 10cm
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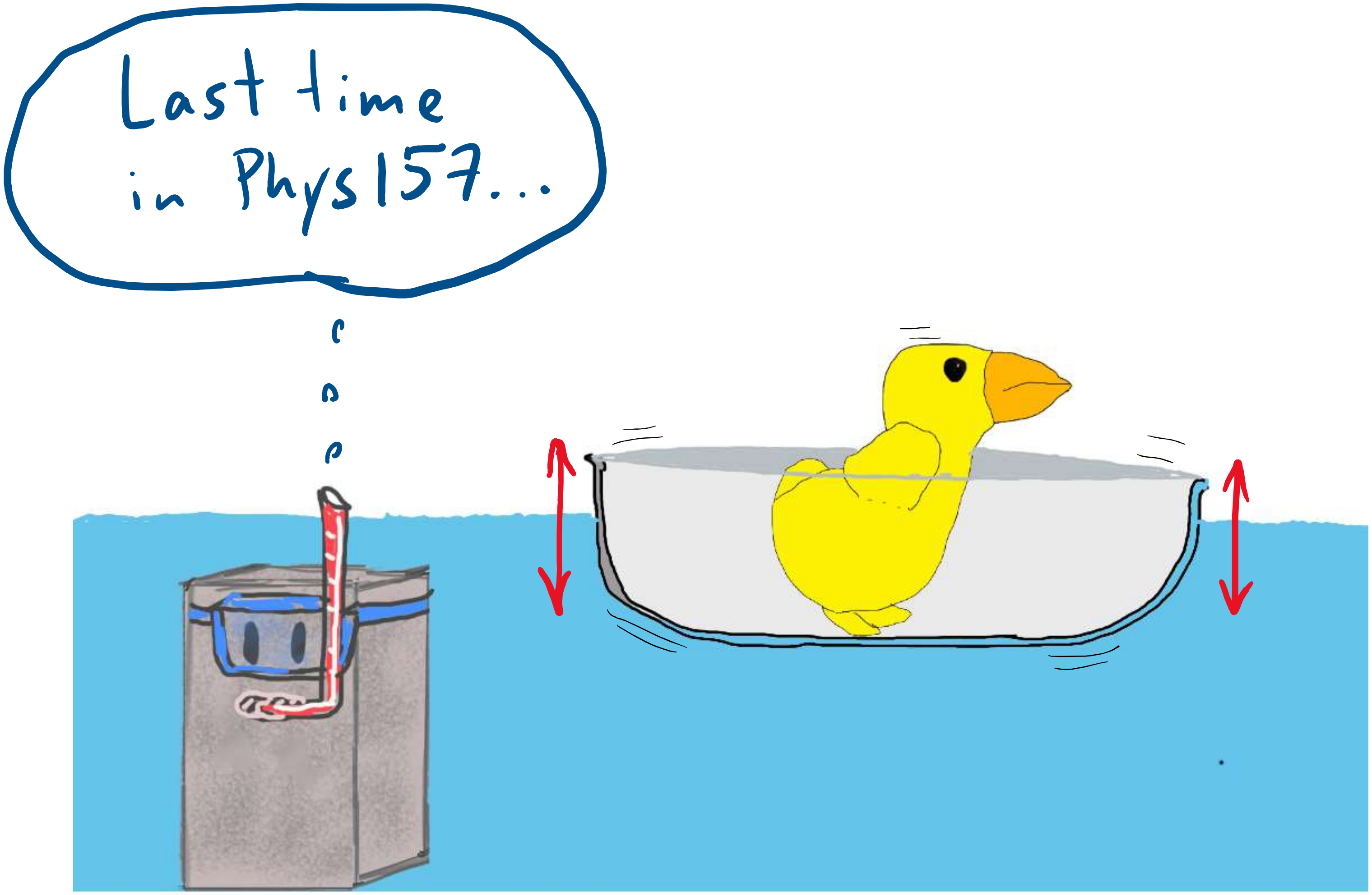
At equilibrium, compression of the spring is determined by $F_{NET} = 0$

$mg = kx$

With different masses, $\overset{1kg}{m_1} g = kx_1$, and $\overset{2kg}{m_2} g = kx_2$, so when we add the extra mass, $\Delta m \cdot g = k \cdot \Delta x$. Thus: $\Delta x = \frac{\Delta m g}{k}$

$= 1cm$


Last time in Phys157...

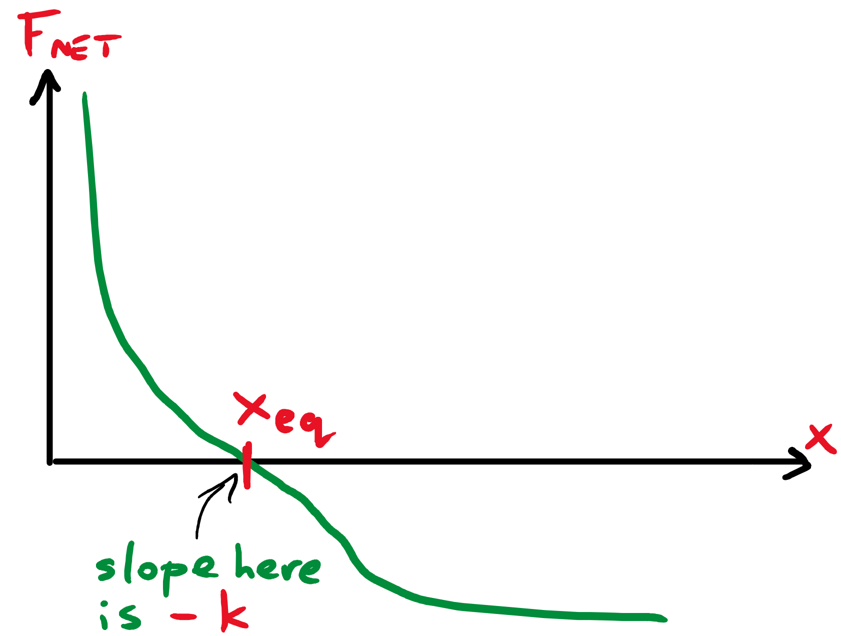
How to find ω in examples:

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

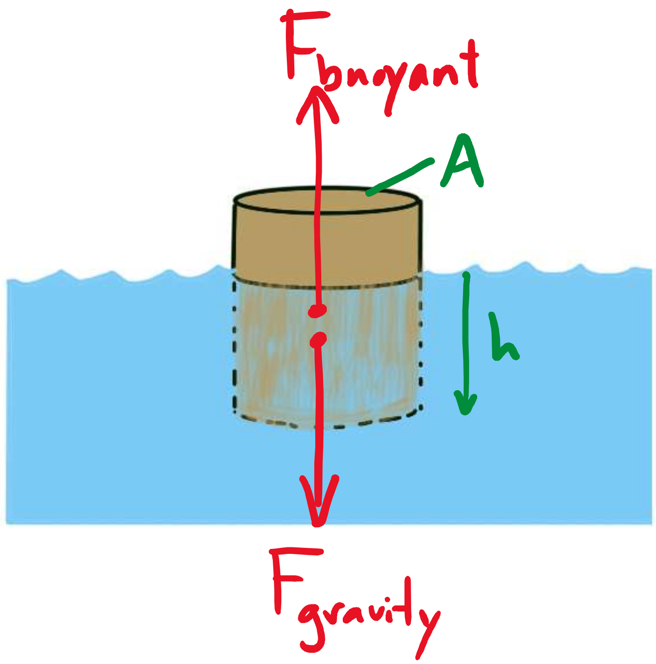
② Find equilibrium value x_{eq} by solving $F_{NET}(x_{eq}) = 0$.

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

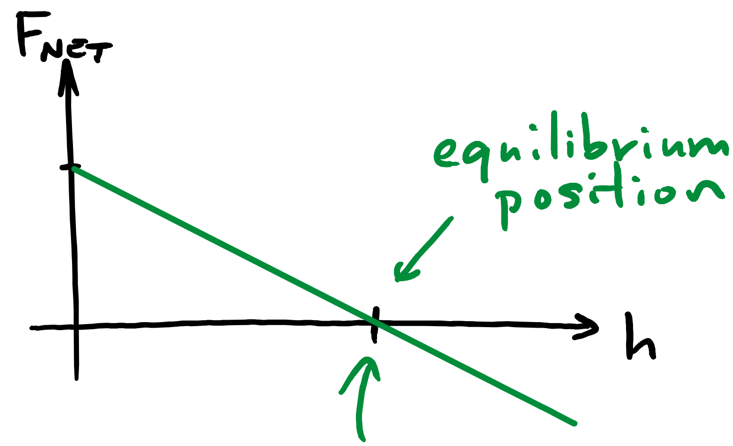
④ Then $\omega = \sqrt{\frac{k}{m}}$



Example: bobbing



$$F_{NET}^{\downarrow} = \overset{\text{gravity}}{mg} - \overset{\text{buoyant}}{g\rho A h}$$

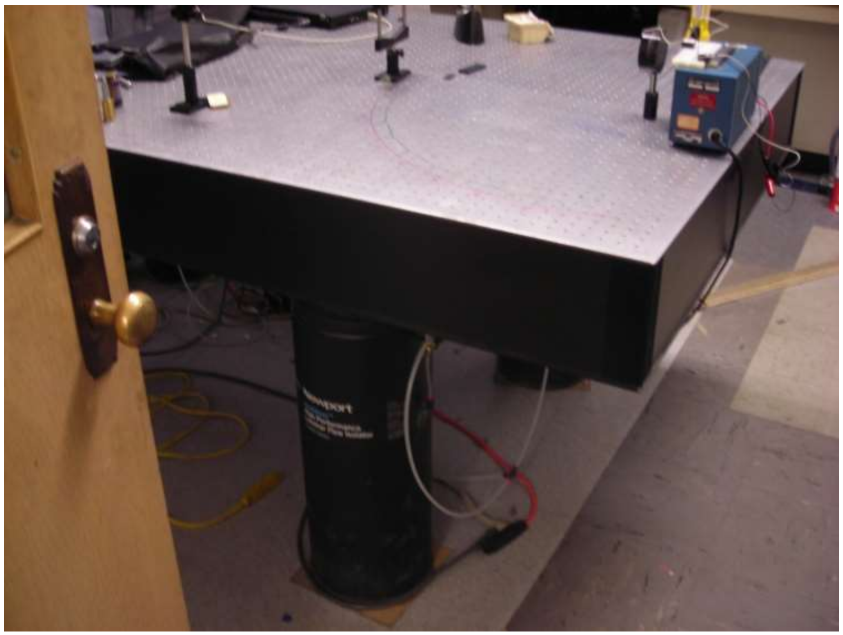


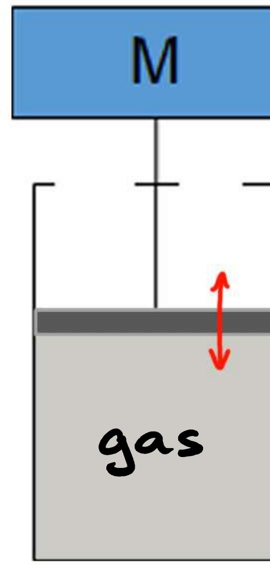
$$k = -\text{slope}_{\text{here}} = g\rho A$$

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

Example: air leg

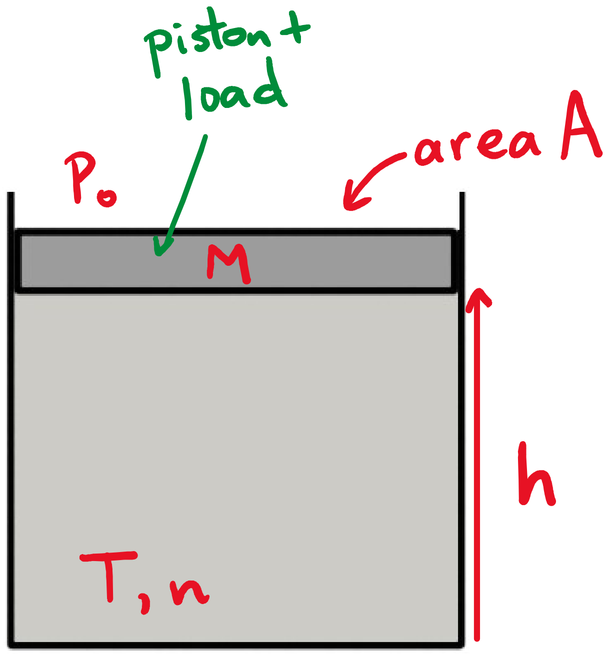
- used to isolate sensitive equipment from vibration.





assume: any motion of piston is slow
so compression/expansion is isothermal

Example: air leg

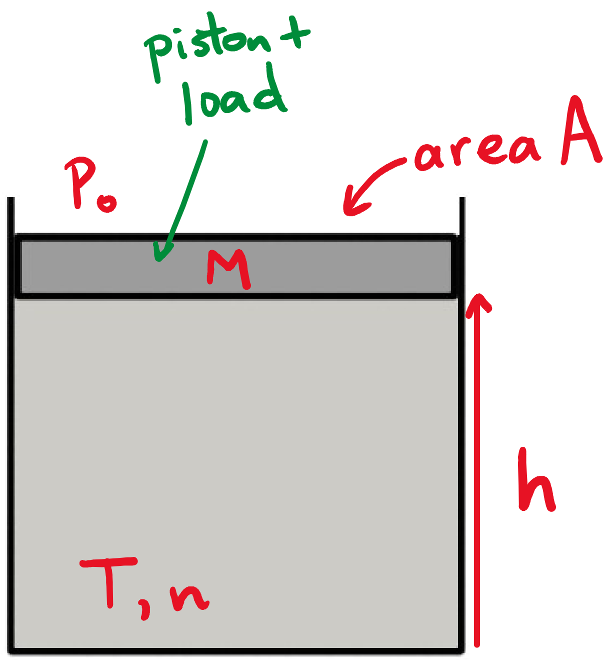


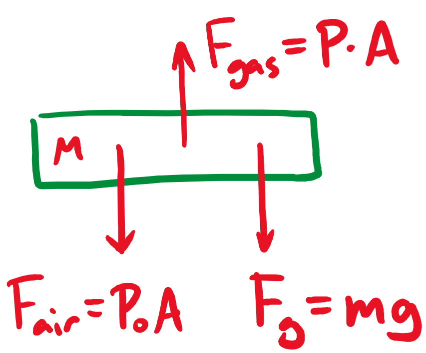
a) Draw a free body diagram for the object of mass M showing the vertical forces.

b) Calculate the magnitude of the net upwards force on the object as a function of the height h of the piston.

Answer in terms of h, n, T, A, M, g, and P_0

Example: air leg





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

b) Calculate the magnitude of the net upwards force on the object as a function of the height h of the piston.

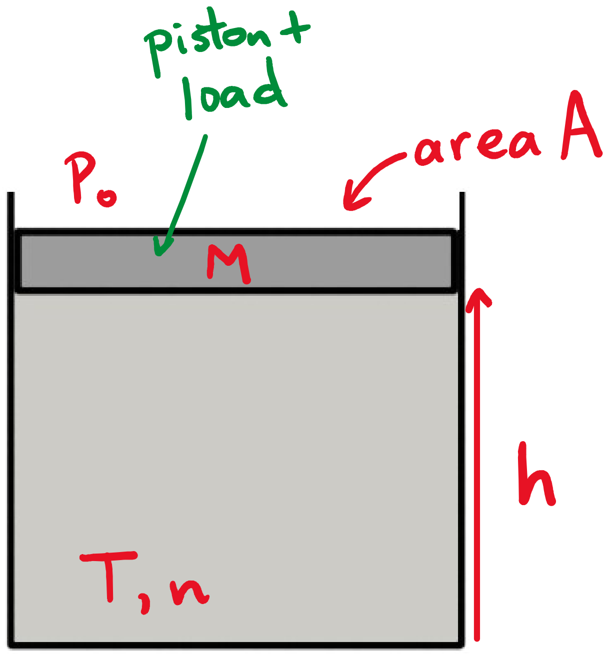
Answer in terms of h, n, T, A, M, g, and P_0

Have: $P = \frac{nRT}{V} = \frac{nRT}{A \cdot h}$

so $F_{gas} = PA = \frac{nRT}{h}$

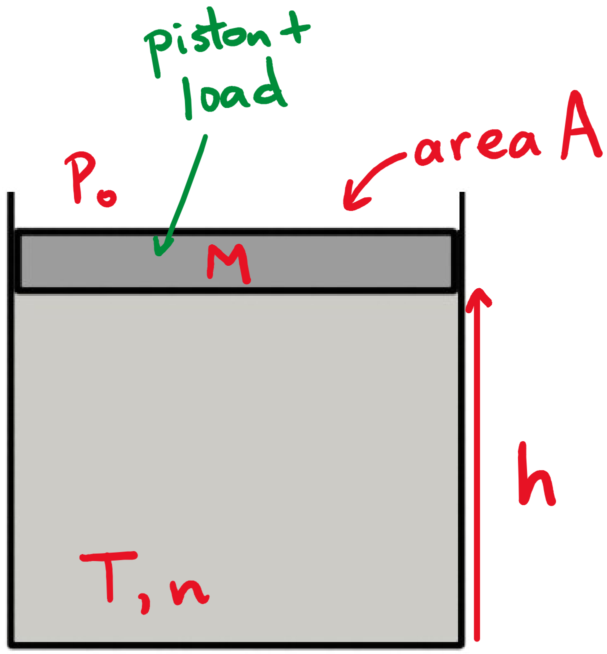
$$F_{NET}^{up} = \frac{nRT}{h} - P_0 A - mg$$

Example: air leg



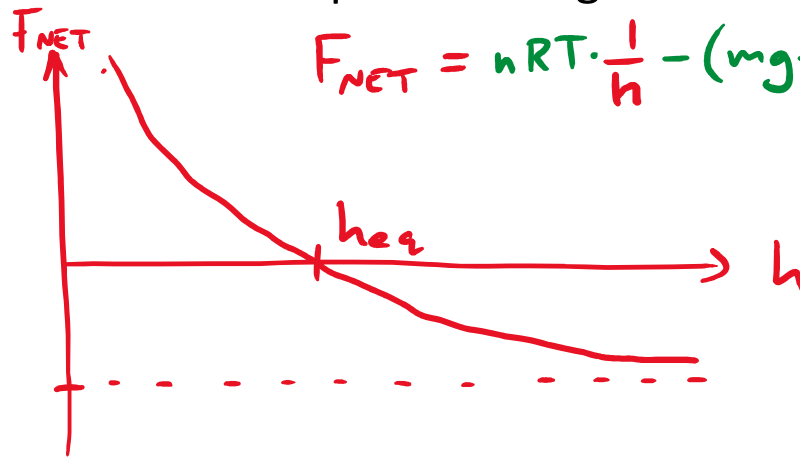
c) Graph this upward force as a function of h, for positive values of h up to the height of the object.

Example: air leg

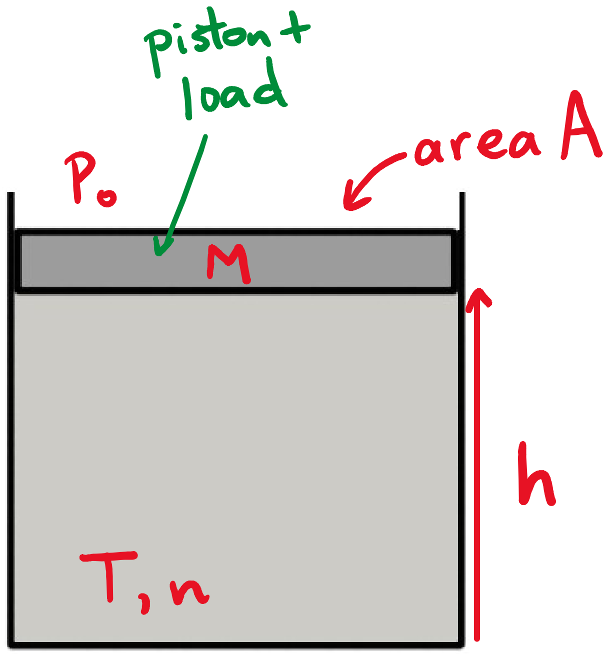


c) Graph this upward force as a function of h, for positive values of h up to the height of the object.

$$F_{NET} = nRT \cdot \frac{1}{h} - (mg + P_0 A)$$



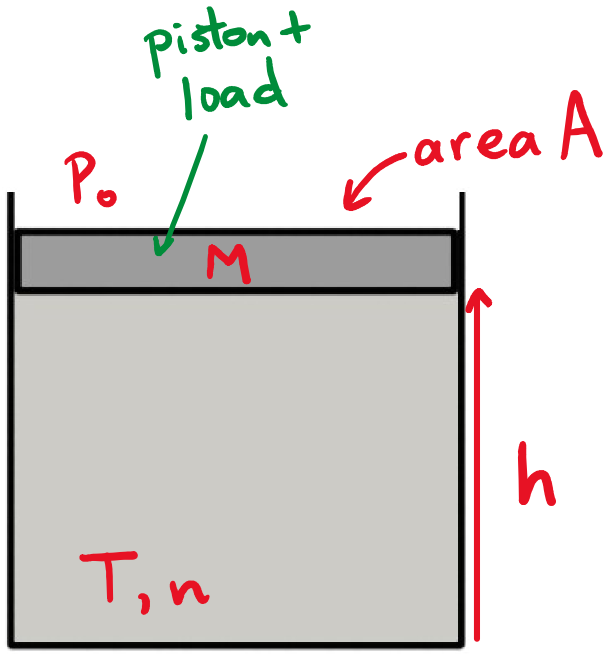
Example: air leg



d) What is the equilibrium height of the piston?

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

Example: air leg



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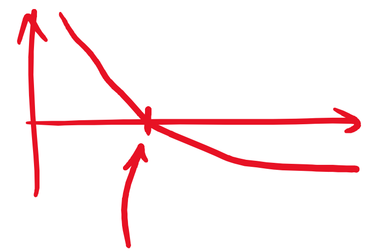


equilibrium height: $F_{NET} = 0$

$$h_{eq} = \frac{nRT}{mg + P_0 A}$$

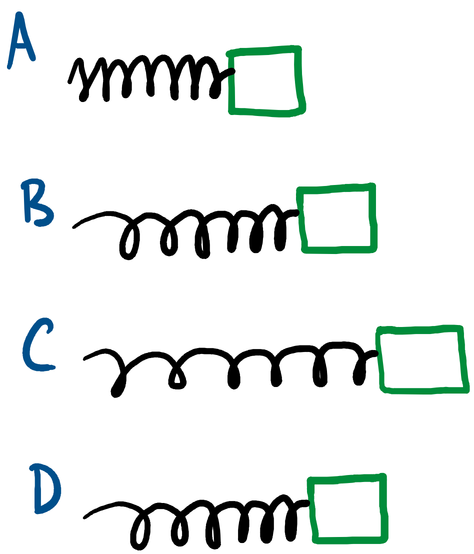
$$k = -\frac{dF}{dh} \text{ at } h_{eq}$$

$$= \frac{nRT}{h_{eq}^2}$$

$$= \frac{(mg + P_0 A)^2}{nRT}$$

Angular Frequency $\omega = \sqrt{\frac{k}{M}} = \frac{mg + P_0 A}{\sqrt{nRTM}}$

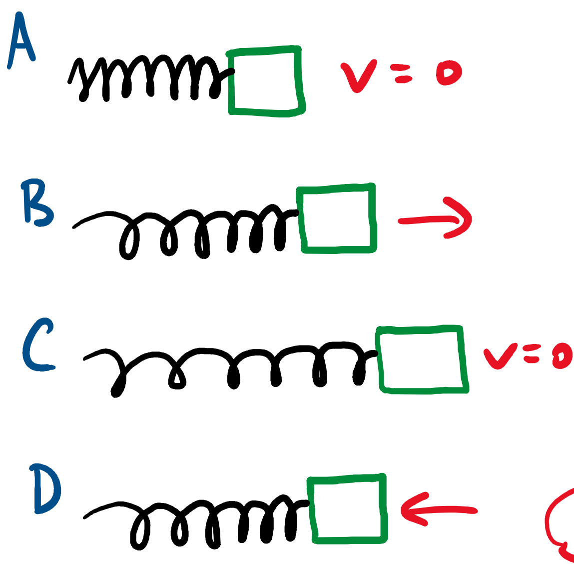
Energy in simple harmonic motion: kinetic energy



The pictures show an object in simple harmonic motions at successive times. Kinetic energy of the system is largest at

A) B
B) D
C) either B or D
D) either A or C
E) The kinetic energy is the same at all times

Energy in simple harmonic motion: kinetic energy



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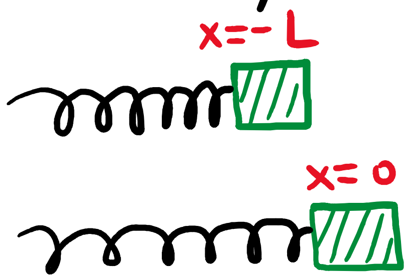
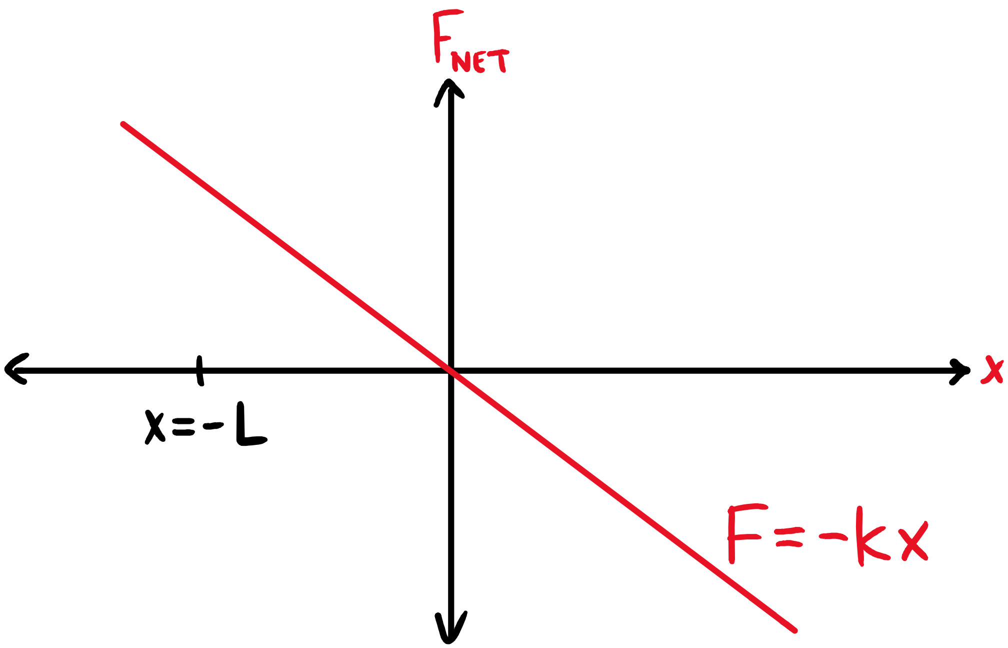
Kinetic energy is $\frac{1}{2}Mv^2$. Largest when object is moving through equilibrium position

Energy in simple harmonic motion



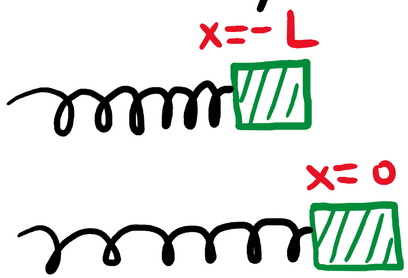


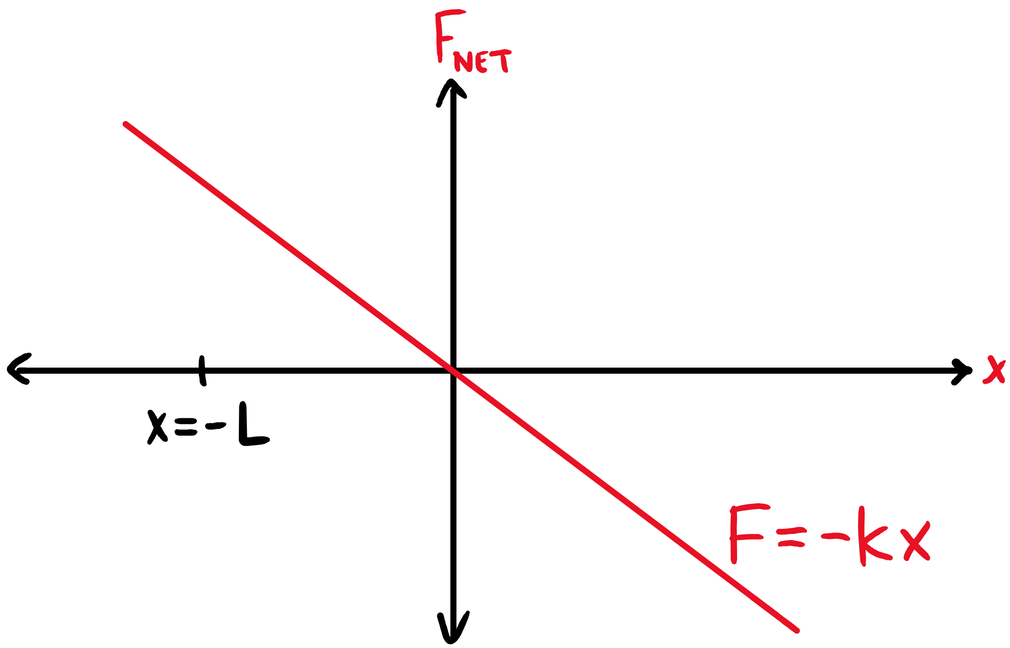
During the motion from x=-L to x=0 (the equilibrium position), what is the net work done **on** the green mass?

Hint: $W = F\,\Delta x$
How do you tell if work is positive or negative?

Click A if you have an answer.
Click B if you are stuck.

Energy in simple harmonic motion

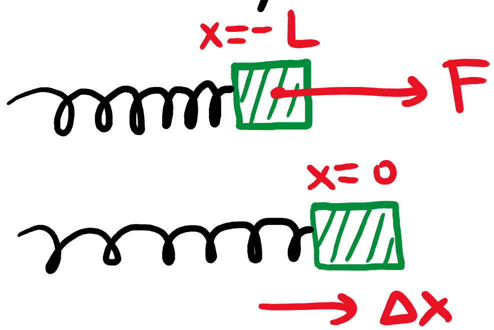




During the motion from x=-L to x=0 (the equilibrium position), the net work done on the green mass is:

A) 0
B) $k L^2$
C) $\frac{1}{2} k L^2$
D) $- k L^2$
E) $- \frac{1}{2} k L^2$

Energy in simple harmonic motion



F + Δx in same direction, so W is positive.

During the motion from x=-L to x=0 (the equilibrium position), the net work done on the green mass is:

F changing so W is sum of F Δx for each infinitesimal step.

A) 0

B) $k\,L^2$

C) $\frac{1}{2}\,k\,L^2$

D) $-\,k\,L^2$

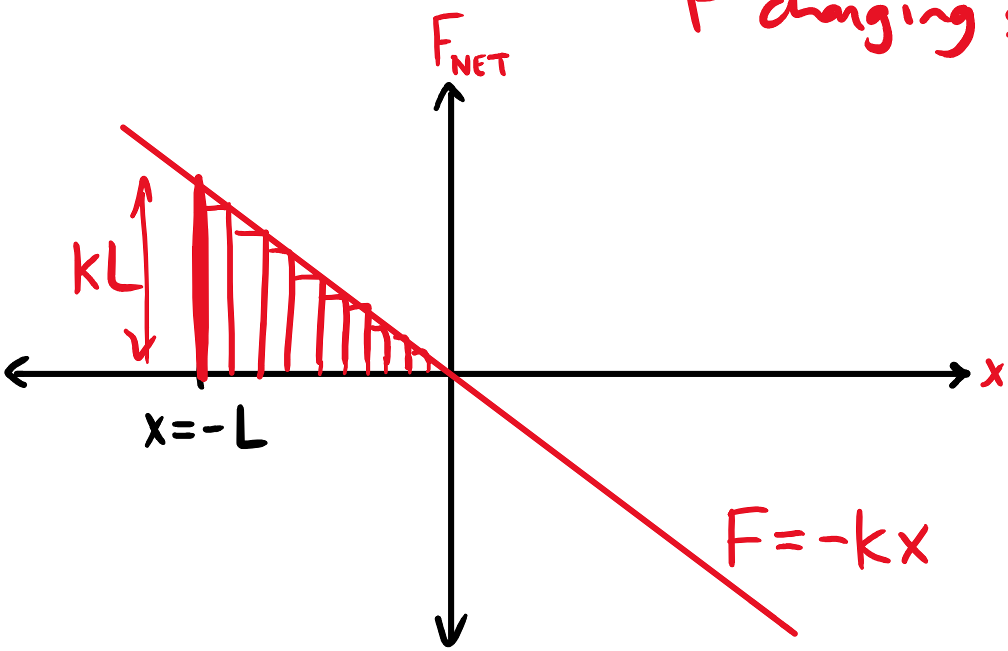
E) $-\,\frac{1}{2}\,k\,L^2$

$\Vert$

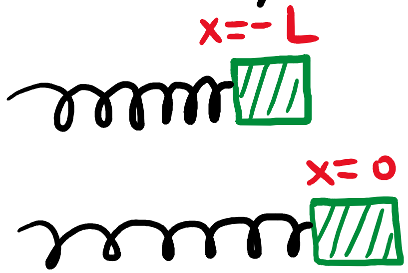
area under F vs x graph

$= \frac{1}{2} \cdot L \cdot kL$

$= \frac{1}{2} kL^2$



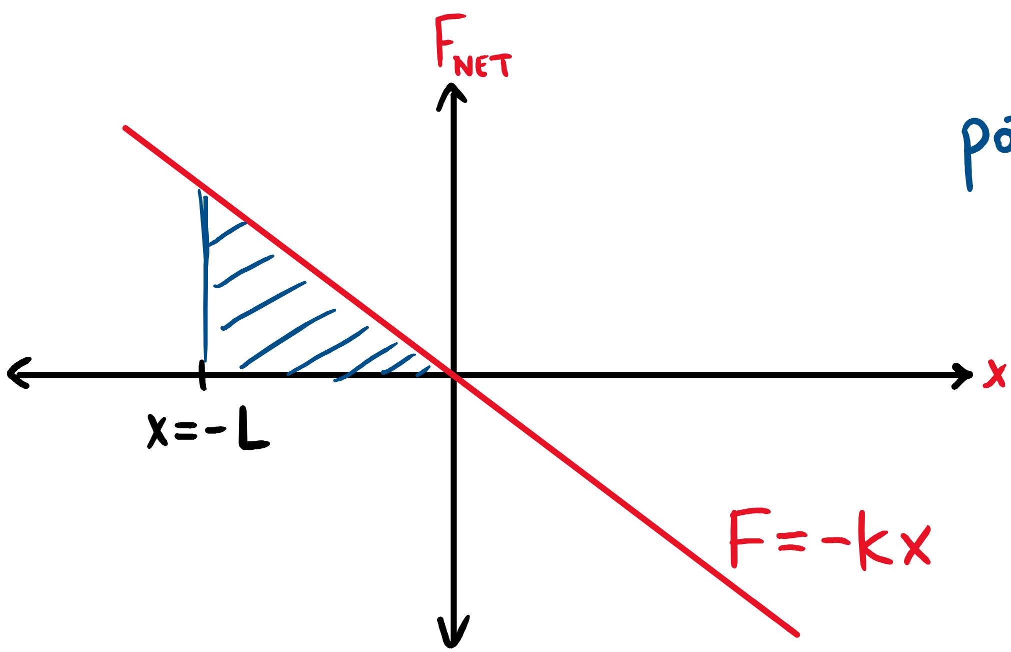
Energy in simple harmonic motion



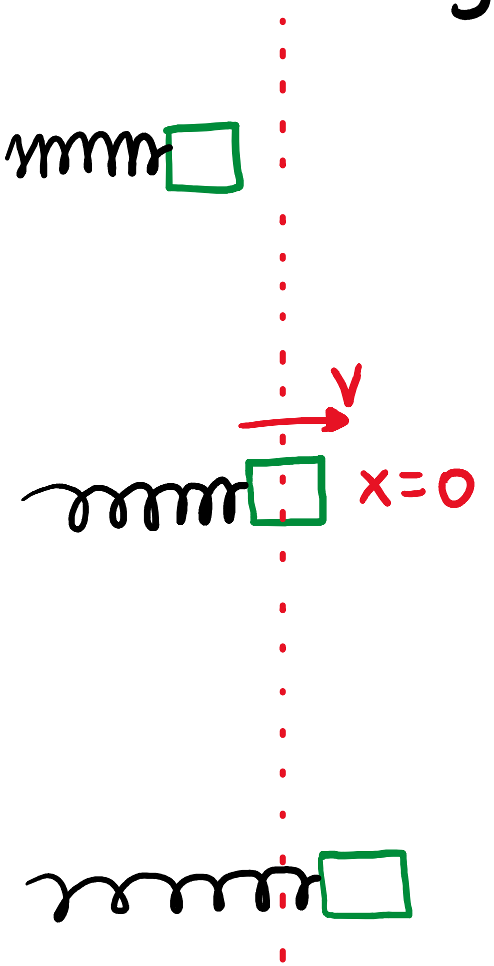
- work done on mass is $\frac{1}{2}kL^2$
- this energy came from the spring

potential energy of spring is:

$$P.E. = \frac{1}{2}kx^2$$



Potential energy in simple harmonic motion.



spring compressed: $P.E. = \frac{1}{2}kx^2$

$K.E. = 0$

equilibrium position: $P.E. = 0$

$K.E. > 0$

spring stretched: $P.E. = \frac{1}{2}kx^2$

$K.E. = 0$