The simulation shows a mass oscillating on a spring without gravity (e.g. a mass sliding on a frictionless table with a horizontal spring)

The potential energy of the system is smallest:

A) When the spring is at its maximum compression
B) When the spring is at its maximum stretching
C) When the spring is in its equilibrium position
D) Either A or B

Office hours today: 4-5pm Hennings 420

Homework sessions: Today 5-7pm Hennings 200
Tuesday 5-7pm Hennings 202

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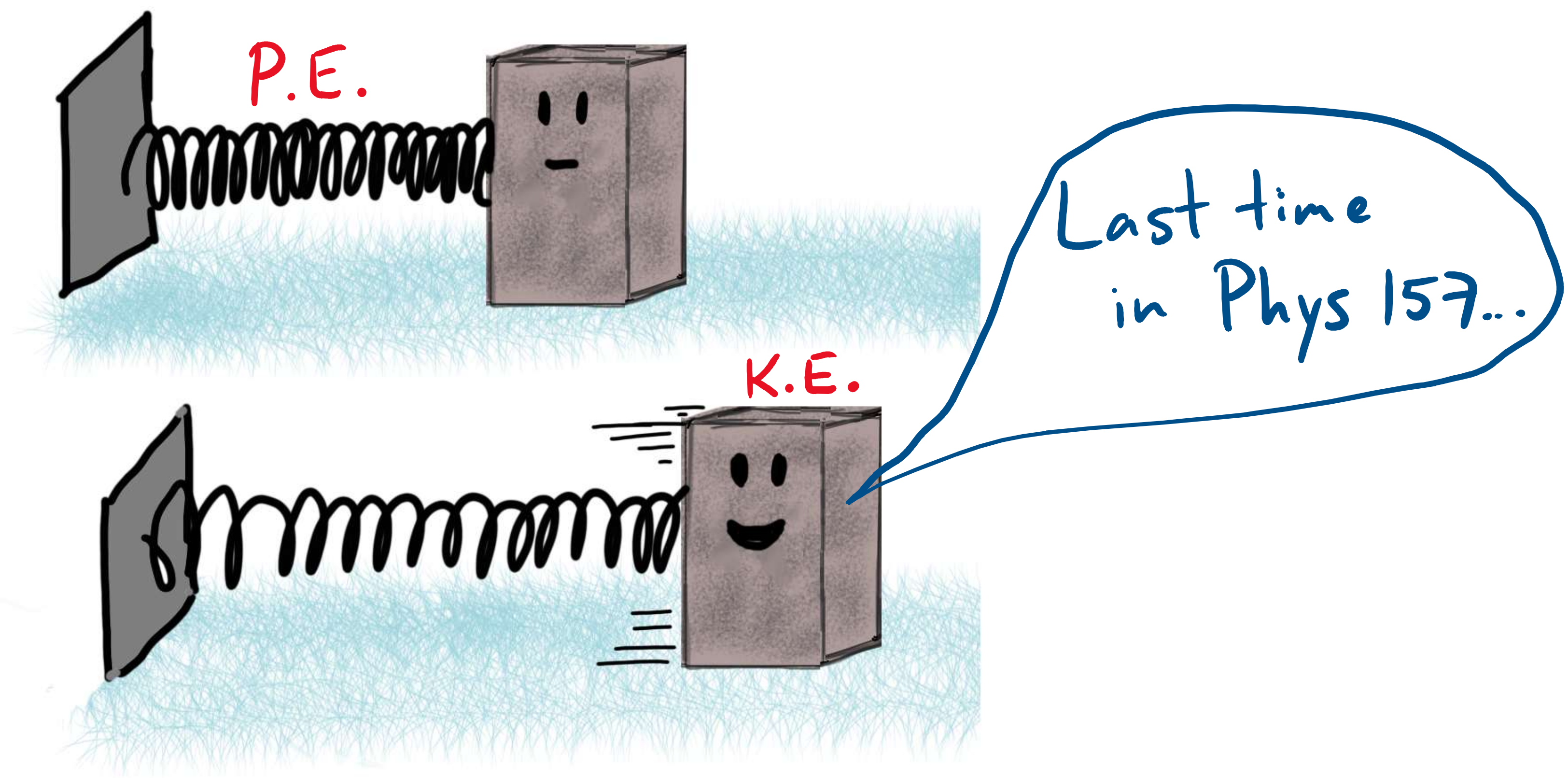
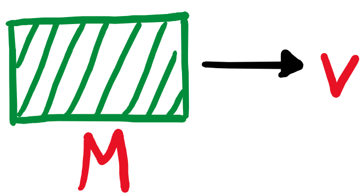
increased potential energy either for stretching or compression


P.E.
K.E.
Last time in Phys 157...

Kinetic energy:



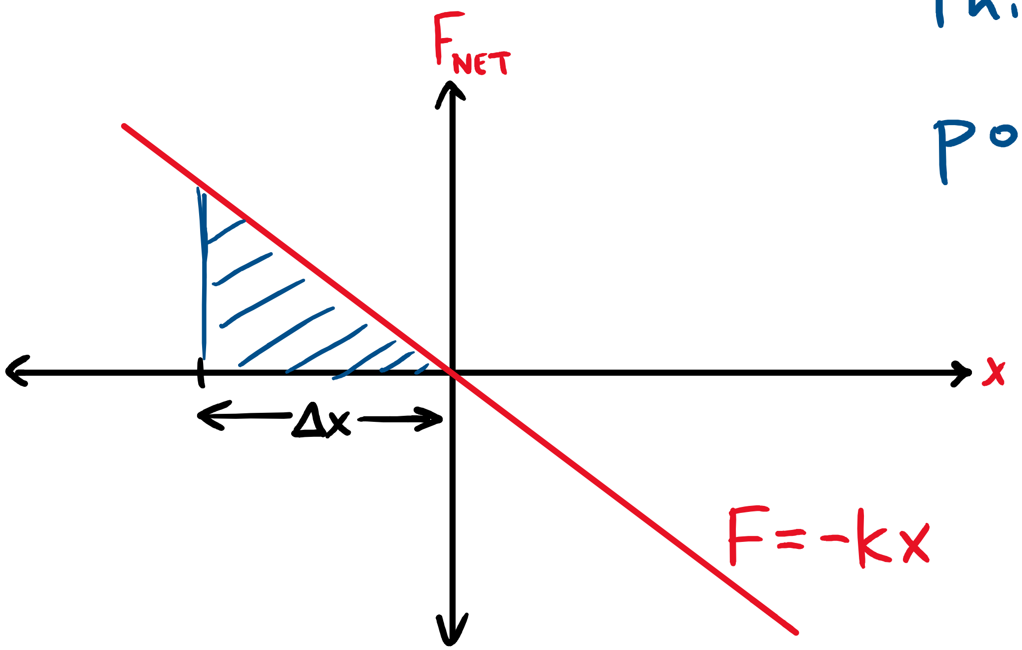
$$K.E. = \frac{1}{2} M v^2$$

(as long as v is much less than the speed of light...)

Energy in a spring:

compressed:

normal:



work done: area under F vs x

$$W = \frac{1}{2}k(\Delta x)^2$$

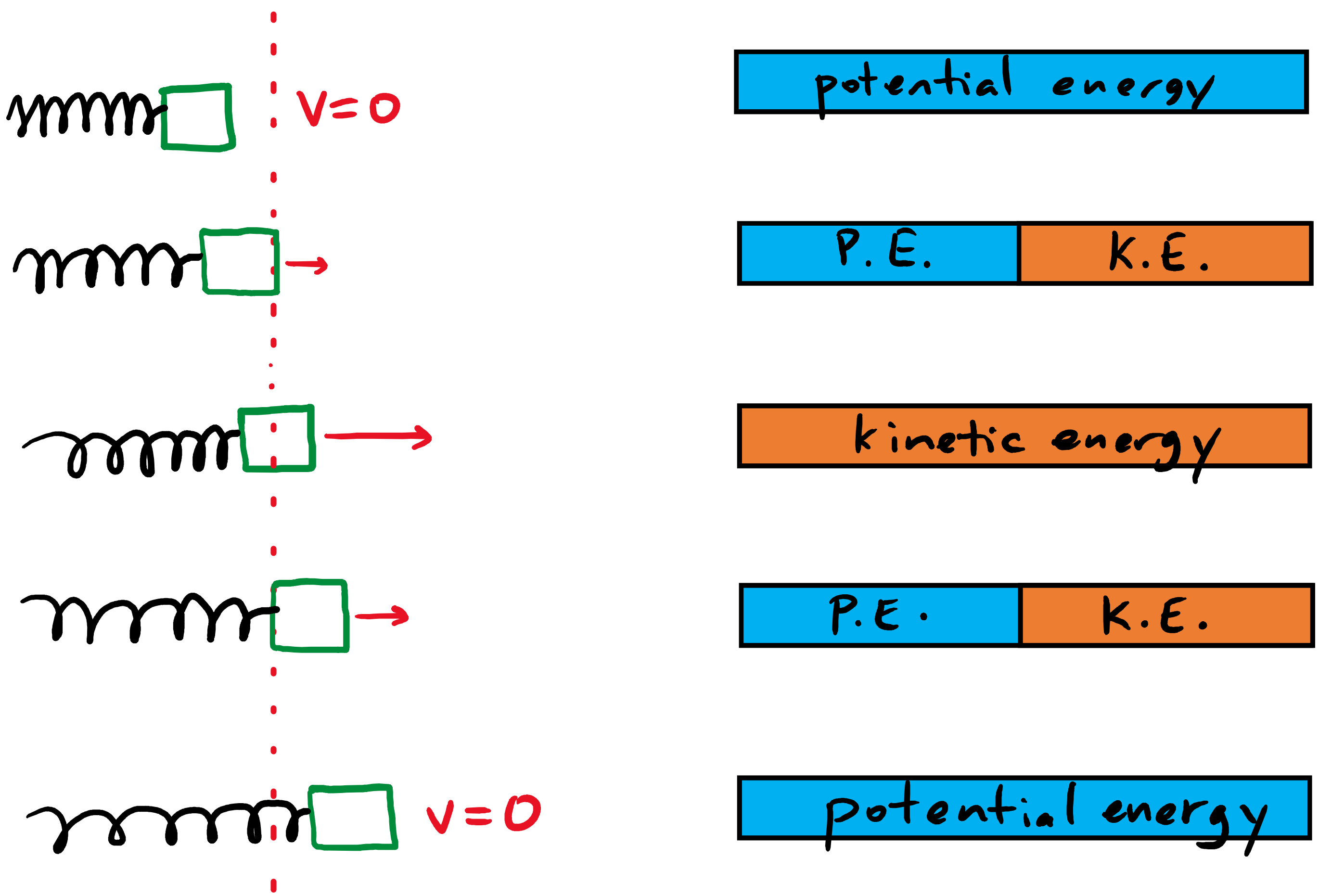
this energy was stored in the spring!

potential energy of spring is:

$$\boxed{P.E. = \frac{1}{2}k(\Delta x)^2}$$

Total energy is conserved $\frac{1}{2}Mv^2 + \frac{1}{2}kx^2 = E$ constant

equal to initial energy



A 0.5 kg mass is attached to a horizontal spring of spring constant 200 N/m. If the spring is initially compressed by 0.1m, and the mass is then released, what is the speed of the block when the spring is at its equilibrium length?

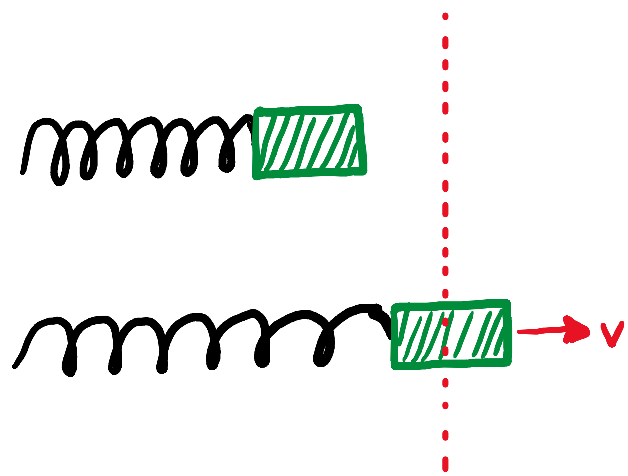
A. 1 m/s

B. 2 m/s

C. 3 m/s

D. 4 m/s

E. 5 m/s



M k

A 0.5 kg mass is attached to a horizontal spring of spring constant 200 N/m. If the spring is initially compressed by 0.1m, and the mass is then released, what is the speed of the block when the spring is at its equilibrium length?

Δx

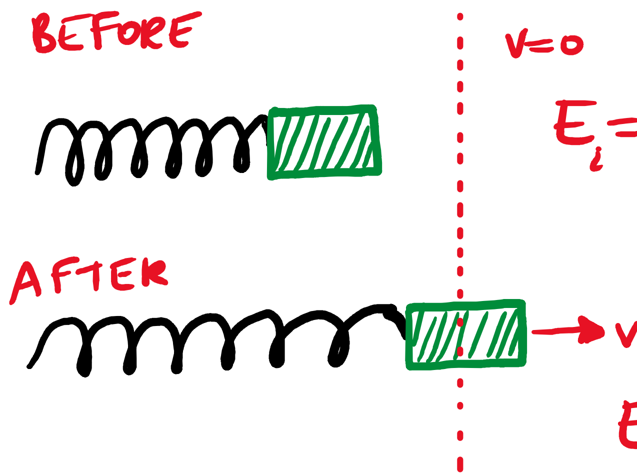
A. 1 m/s

B. 2 m/s

C. 3 m/s

D. 4 m/s

E. 5 m/s



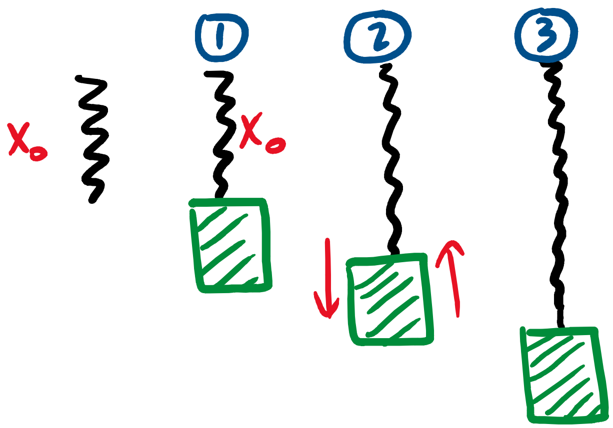
$v = 0$

$E_i = \frac{1}{2} k (\Delta x)^2$

$\Delta x = 0$

$E_f = \frac{1}{2} M v^2$

Energy conserved: $\frac{1}{2} M v^2 = \frac{1}{2} k (\Delta x)^2 \Rightarrow v = \sqrt{\frac{k}{m}} \cdot \Delta x = 2 \text{ m/s}$



A mass is attached to a vertical spring at its normal length, and then oscillates about some equilibrium position. During the oscillations, the total potential energy of the system is smallest

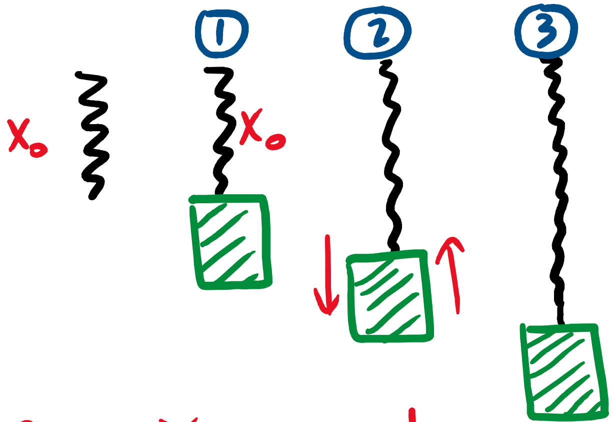
A) In position 1

B) In position 2

C) In position 3

D) Either in position 1 or position 3

E) There is not enough information to answer



A mass is attached to a vertical spring at its normal length, and then oscillates about some equilibrium position. During the oscillations, the total potential energy of the system is smallest

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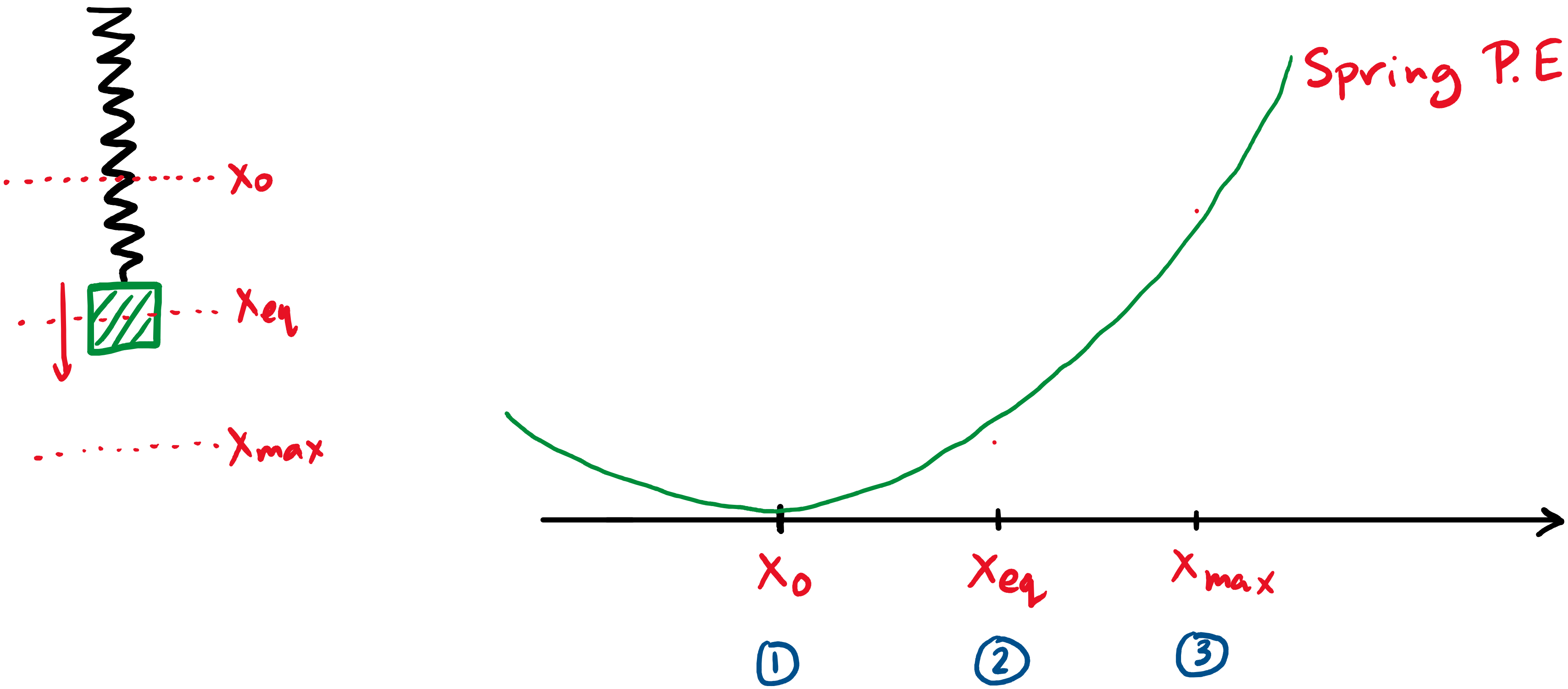
E) There is not enough information to answer

energy conserved

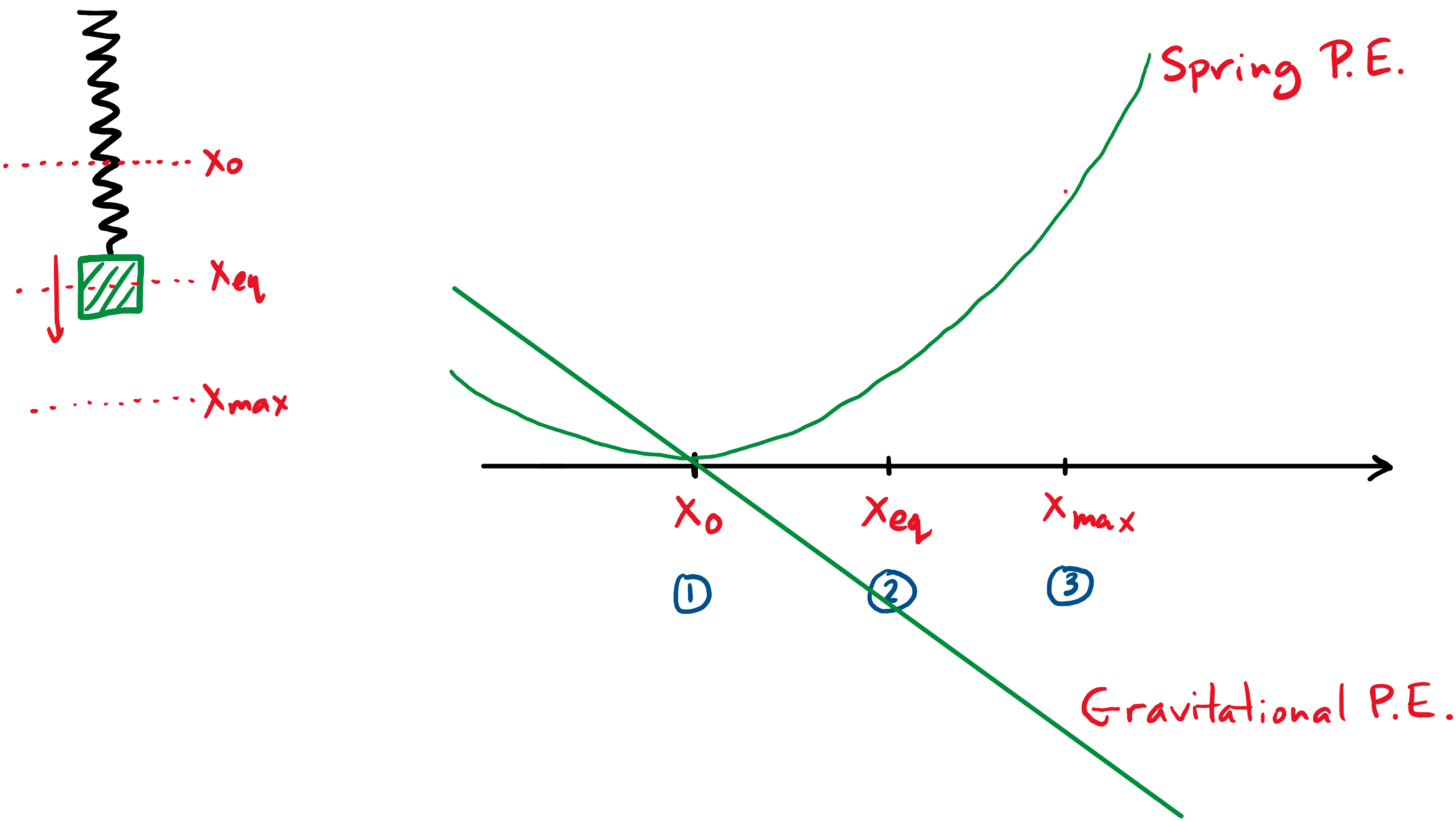
P.E. + K.E. is constant.

- P.E. is smallest when K.E. is largest

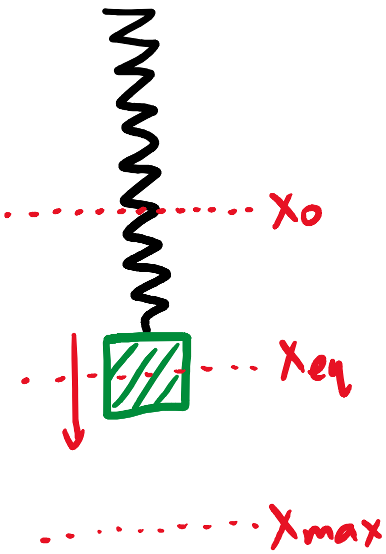
- position 2

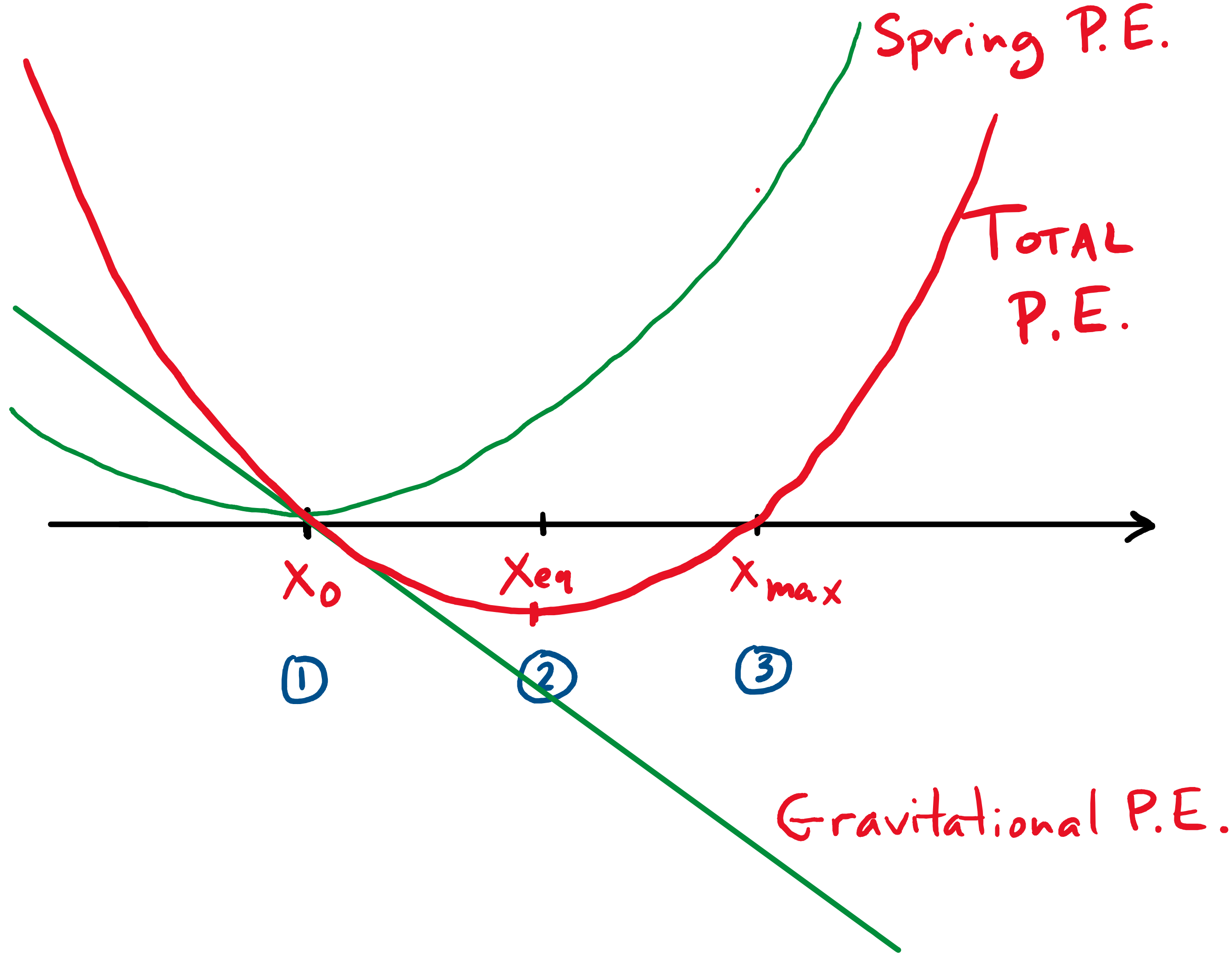


x_o
x_{eq}
x_{max}
Spring P.E.
x_o
x_{eq}
x_{max}
1
2
3

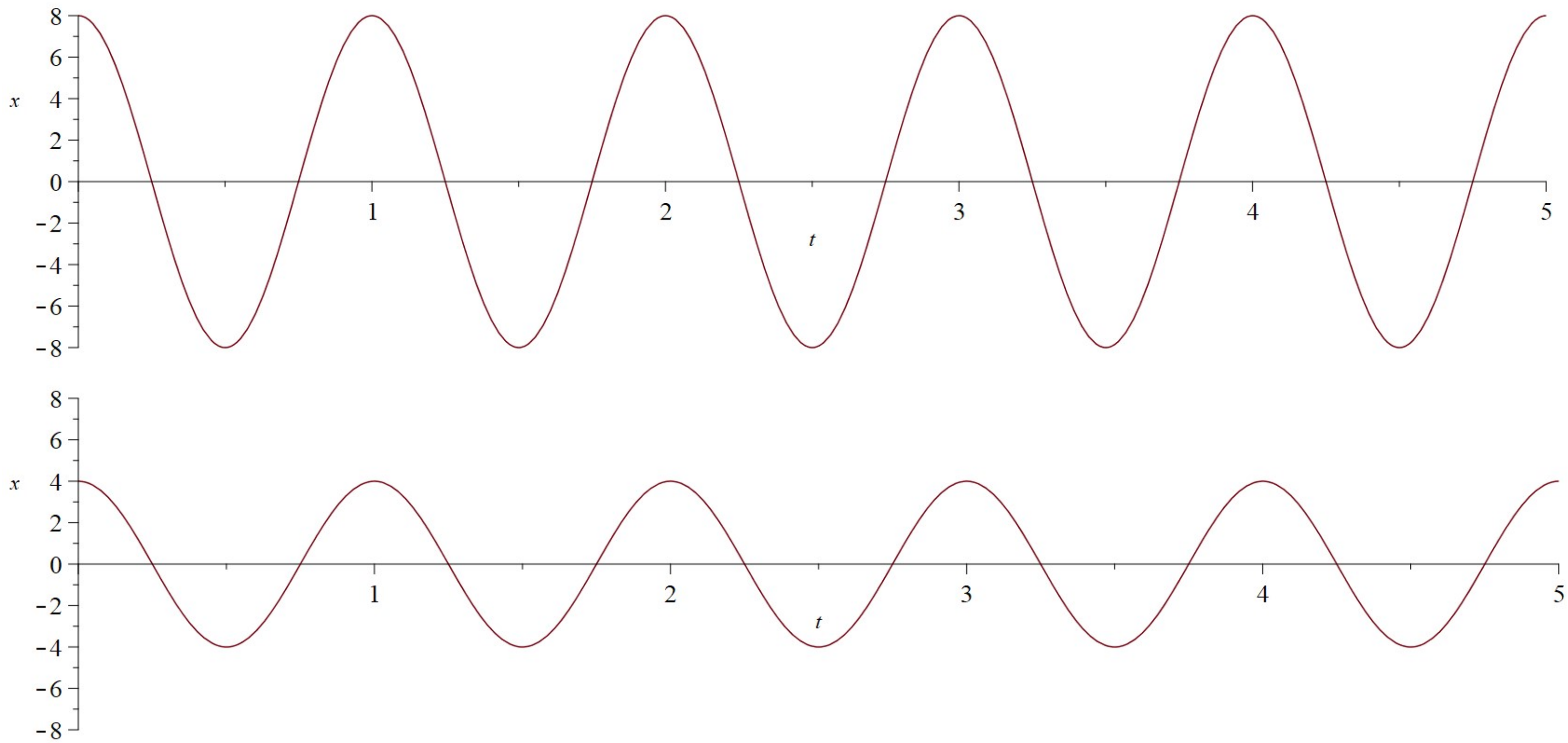


x_0
x_{eq}
x_{max}
Spring P.E.
x_0
x_{eq}
x_{max}
1
2
3
Gravitational P.E.



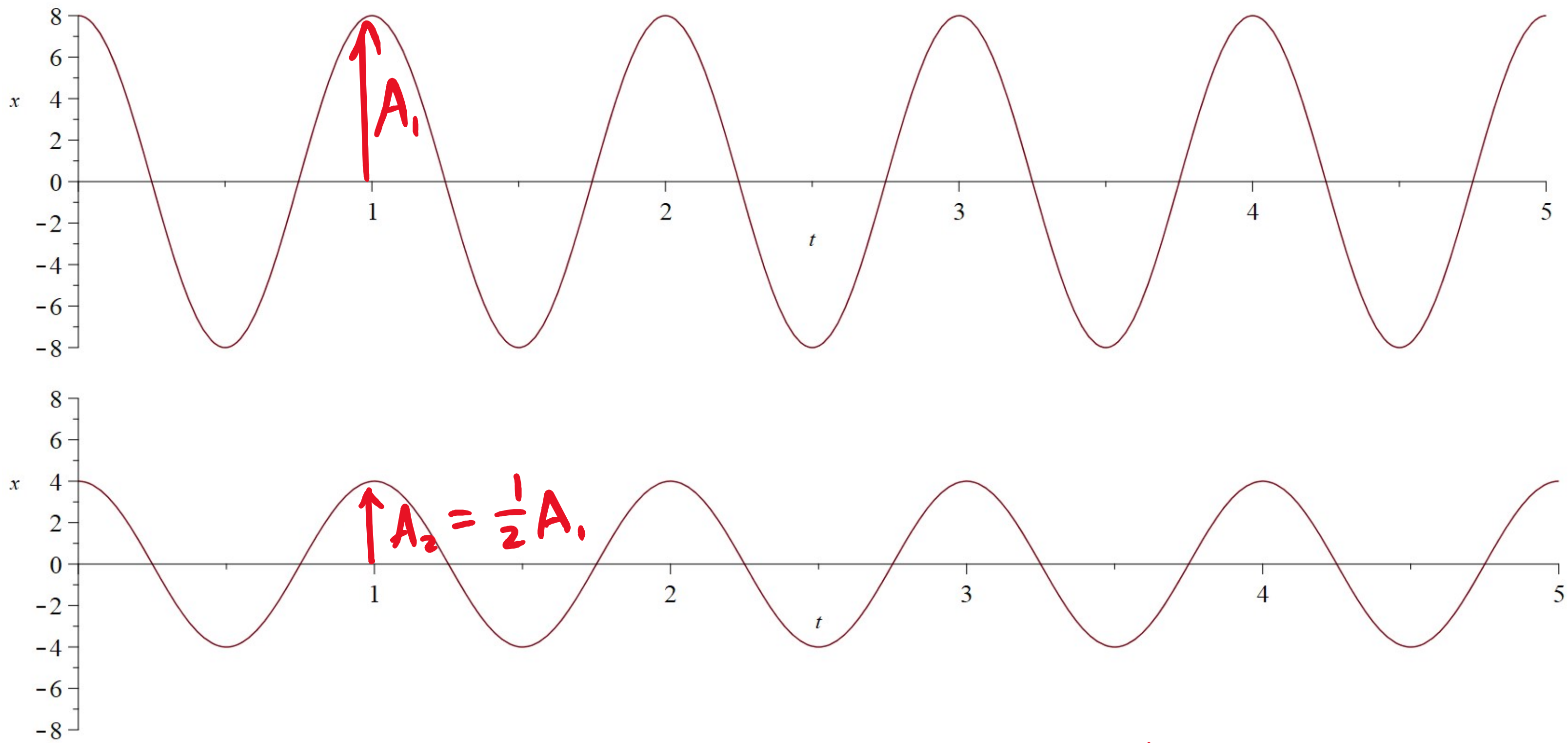


Total P.E. is minimum at equilibrium position.



The two graphs show different oscillations for the same system. Compared with the first case, the total potential plus kinetic energy in the second case is

A) The same B) Twice as big C) Half as big D) One quarter as big E) One 16th as big



for each: energy same at all times. Look at time when $v=0$.

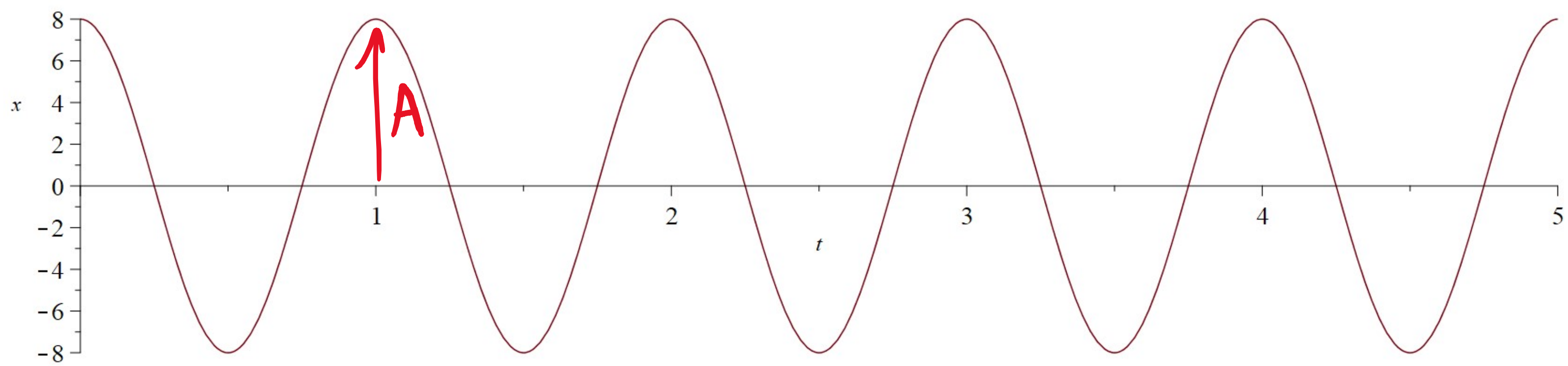
The two graphs show different oscillations for the same system. Compared with the first case, the total potential plus kinetic energy in the second case is

Then $E = \frac{1}{2} k A^2$ so $\frac{E_2}{E_1} = \frac{A_2^2}{A_1^2} = \frac{1}{4}$

A) The same B) Twice as big C) Half as big D) One quarter as big E) One 16th as big

Key fact about oscillating systems:

Energy is proportional to amplitude squared



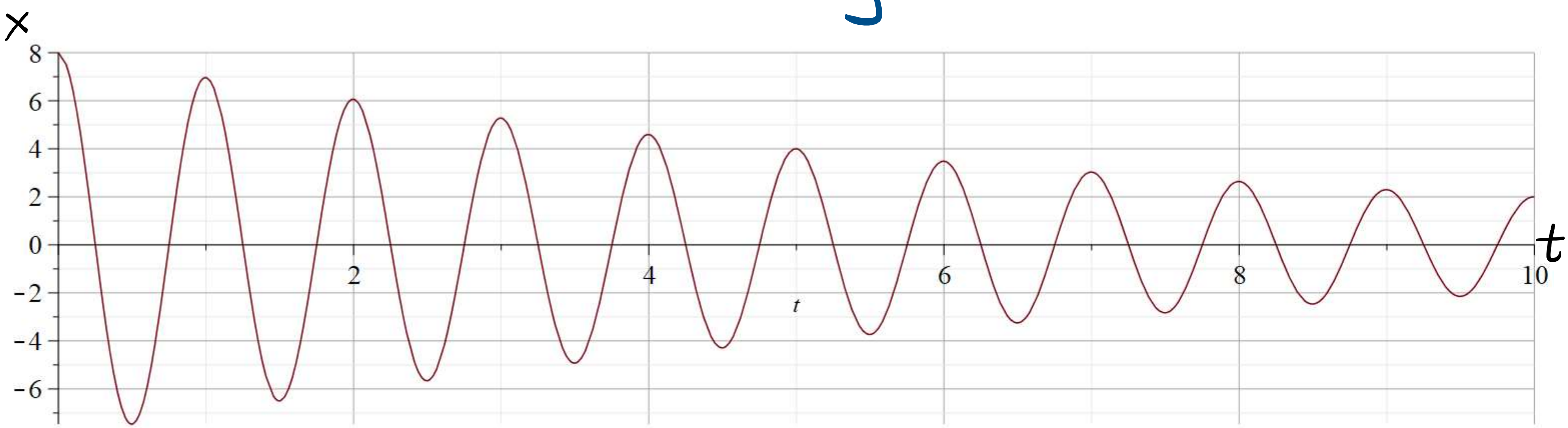
$$E_{TOT} \propto A^2$$

Real oscillators: energy is lost

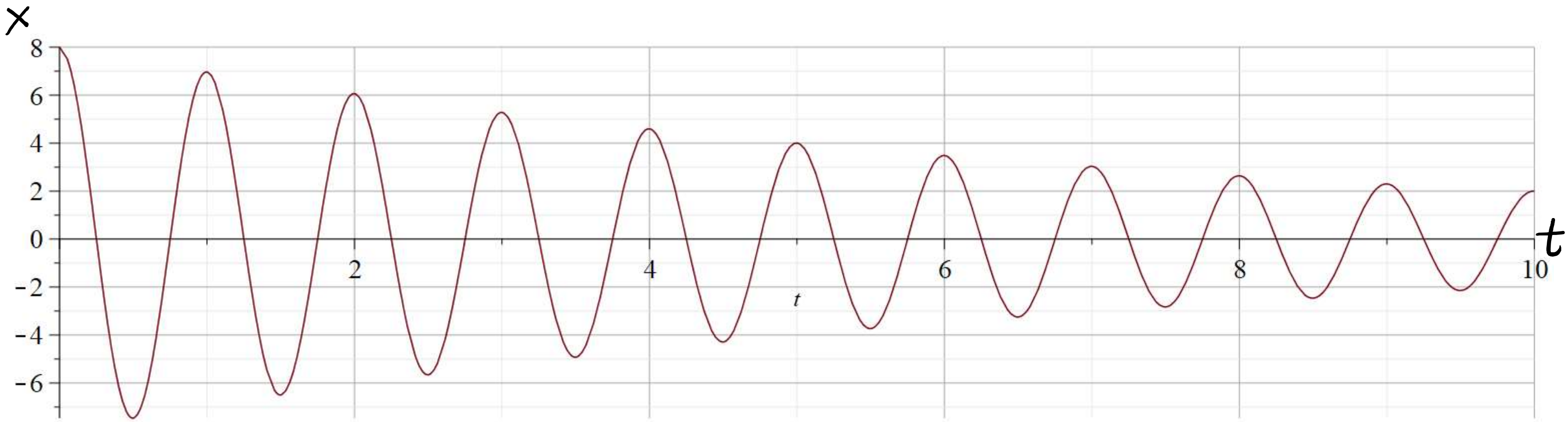
friction

air/fluid drag

heating of system



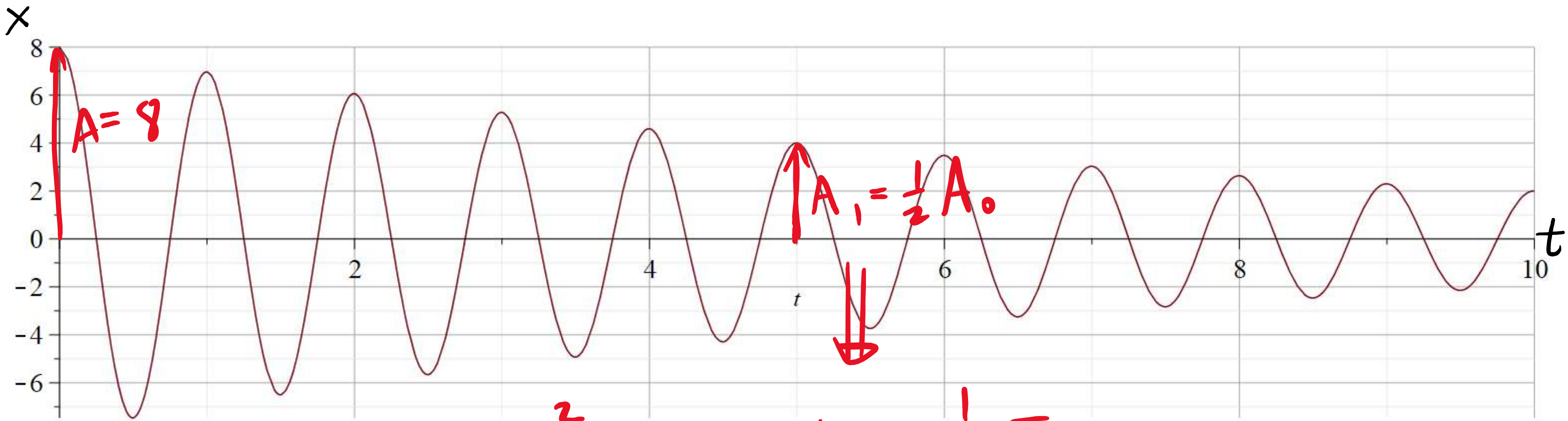
amplitude decreases with time



What fraction of the original kinetic + potential energy remains in the oscillator at t=5s?

A) All of it.
B) Half of it.
C) One quarter of it.
D) $1/\sqrt{2}$ of it.

EXTRA: what fraction of the energy at t=5s remains at t=10s?



$E \propto \text{amplitude}^2$ $E_1 = \frac{1}{4} E_0$

What fraction of the original kinetic + potential energy remains in the oscillator at t=5s?

A) All of it.
B) Half of it.
C) One quarter of it.
D) $1/\sqrt{2}$ of it.

EXTRA: what fraction of the energy at t=5s remains at t=10s? $\frac{1}{4}$

Common situation: amplitude decreases by ~ same fraction each full oscillation.

example: $t = 0 \longrightarrow A = A_0$

fraction

$t = T \longrightarrow A = A_0 \cdot r$

$t = 2T \longrightarrow A = A_0 \cdot r^2$

$t = 3T \longrightarrow A = A_0 \cdot r^3$

number of periods

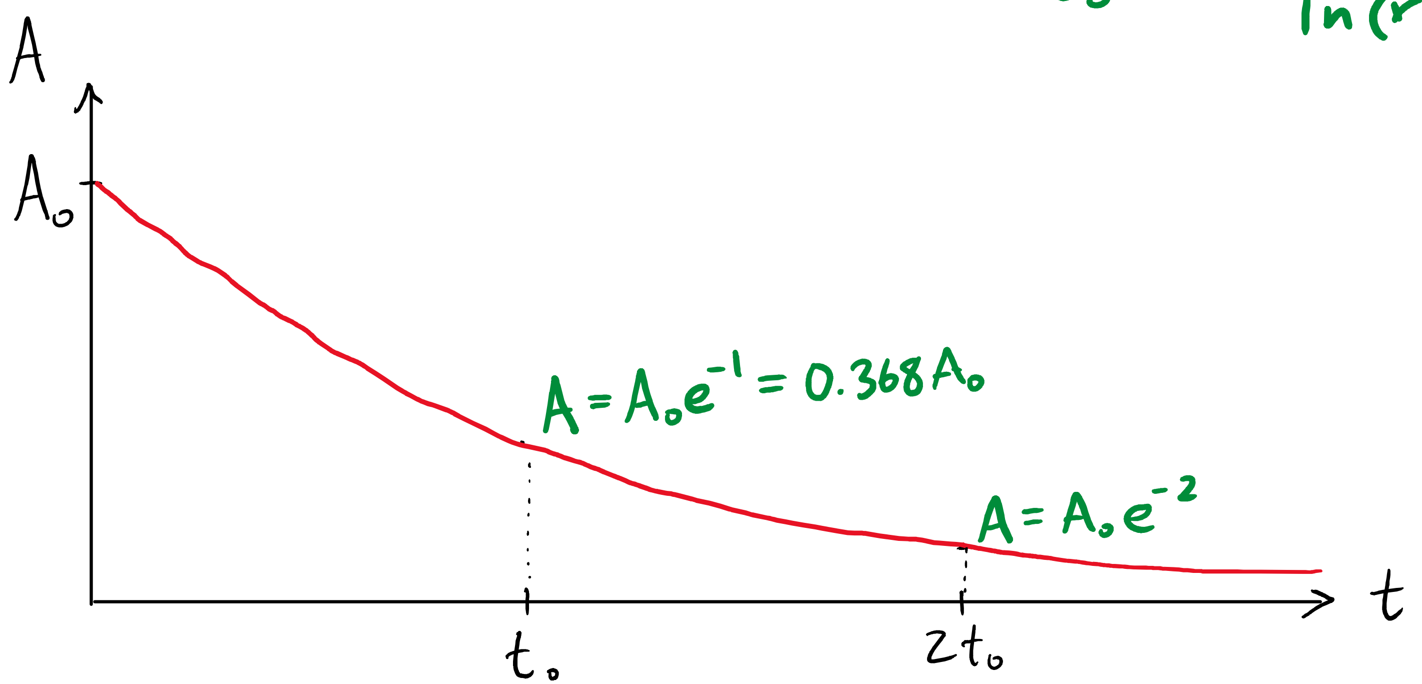
general $T \longrightarrow A = A_0 \cdot r^{t/T}$

Exponential decay

We can rewrite this as:

$$\boxed{A = A_0 e^{-t/t_0}}$$

$$t_0 = -\frac{T}{\ln(r)}$$



Exponential decay

We can rewrite this as:

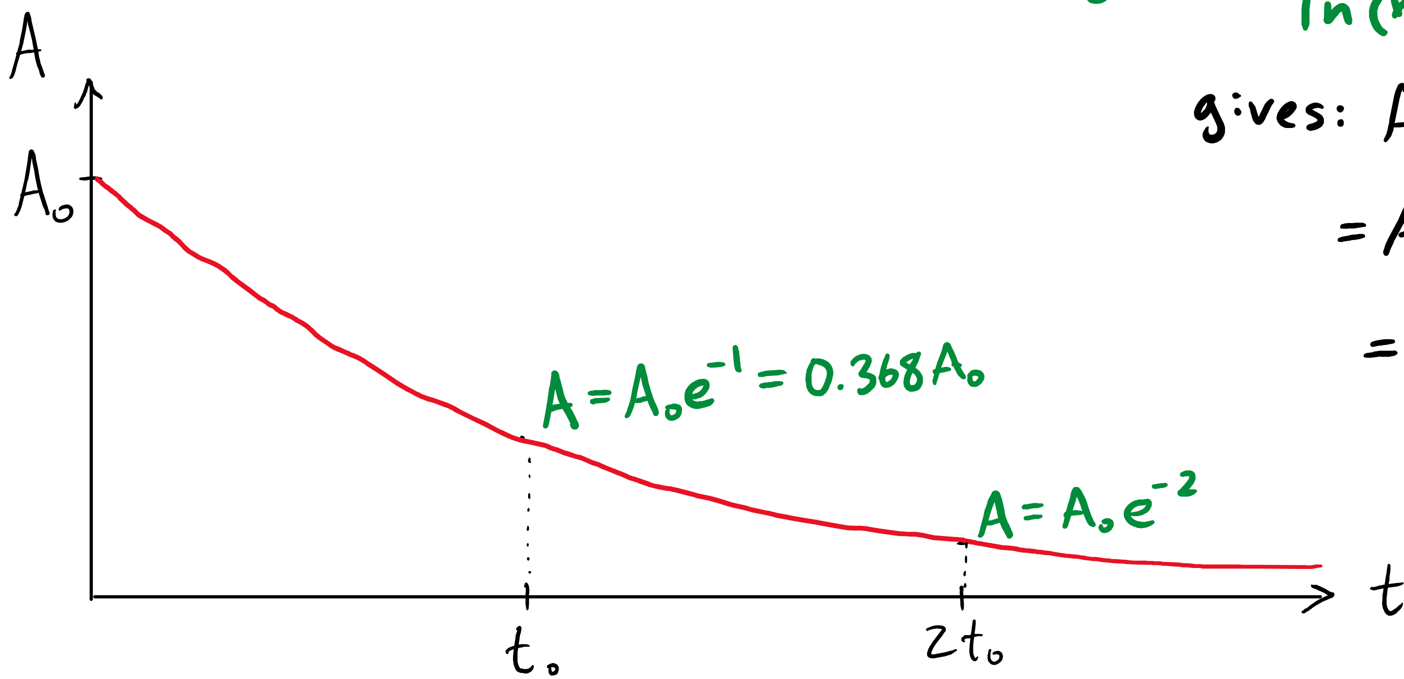
$$\boxed{A = A_0 e^{-t/t_0}}$$

$$t_0 = -\frac{T}{\ln(r)}$$

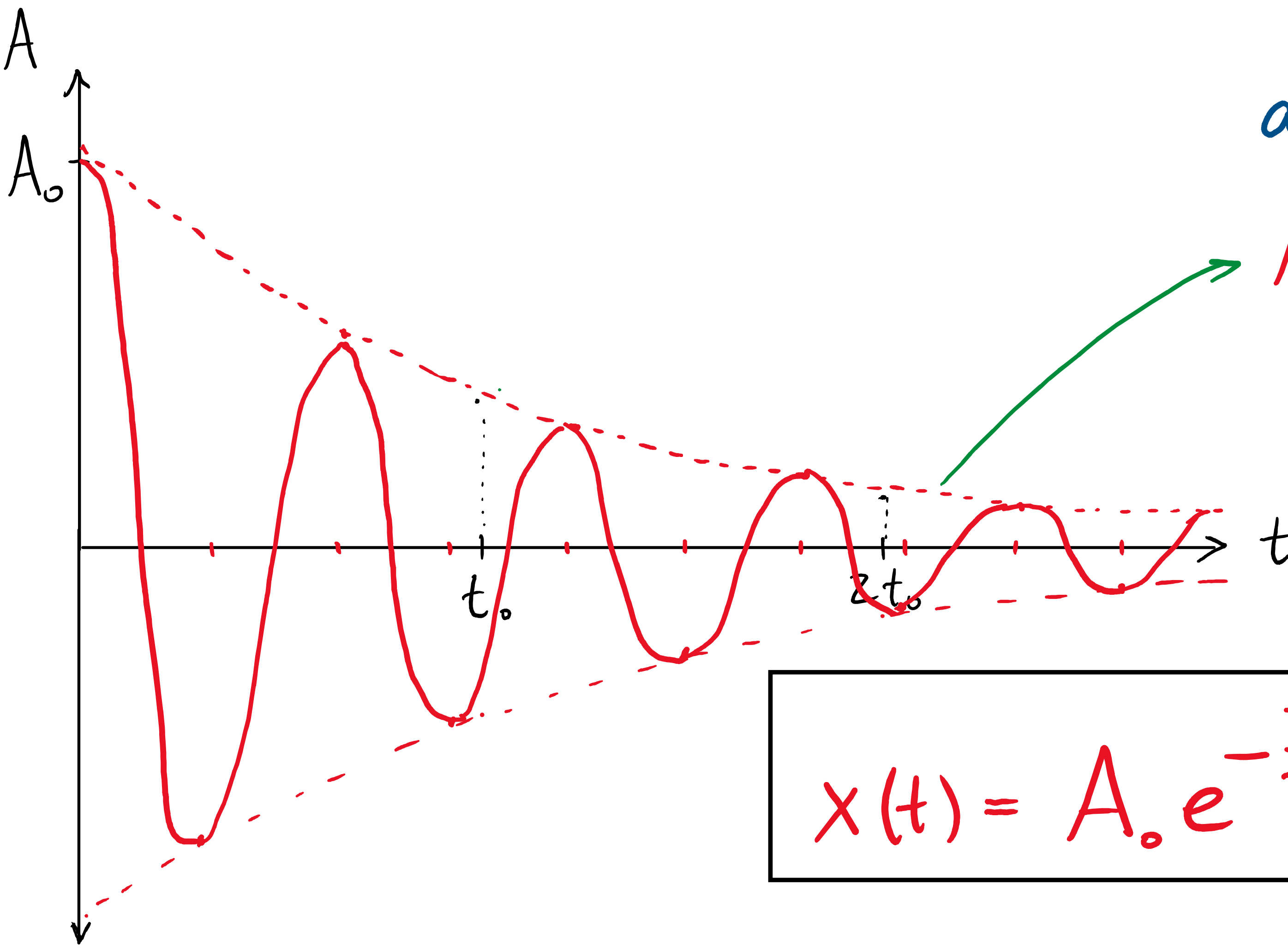
gives: $A_0 e^{\ln(r)\cdot\frac{t}{T}}$

$= A_0 e^{\ln(r^{t/T})}$

$= A_0 r^{t/T}$



Damped oscillations



amplitude:

$$A = A_0 e^{-\frac{t}{t_0}}$$

multiplies cosine

$$\boxed{x(t) = A_0 e^{-\frac{t}{t_0}} \cos(\omega t + \phi)}$$