May 2, Week 15

Today: Chapter 14, Periodic Motion

Homework #11 due Monday, May 7 at 11:59pm
Mastering Physics: 5 problems from chapter 13
Written: none.

Final Exam, Wednesday, May 9, 10:00-12:00 AM.

Review Sessions, Monday and Tuesday afternoon. Time and Place: TBD.

Survey

Which of the following time slots works best for a review session?

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(a) 1:00-2:00

(b) 2:00-3:00

(c) 3:00-4:00

(d) 4:00-5:00

Periodic Motion

Periodic Motion or Oscillation - Any repeated motion.

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$$\boxed{f = \frac{1}{T}}$$ Unit: $\frac{1}{s} = Hz$ (Hertz)

Simple Harmonic Motion

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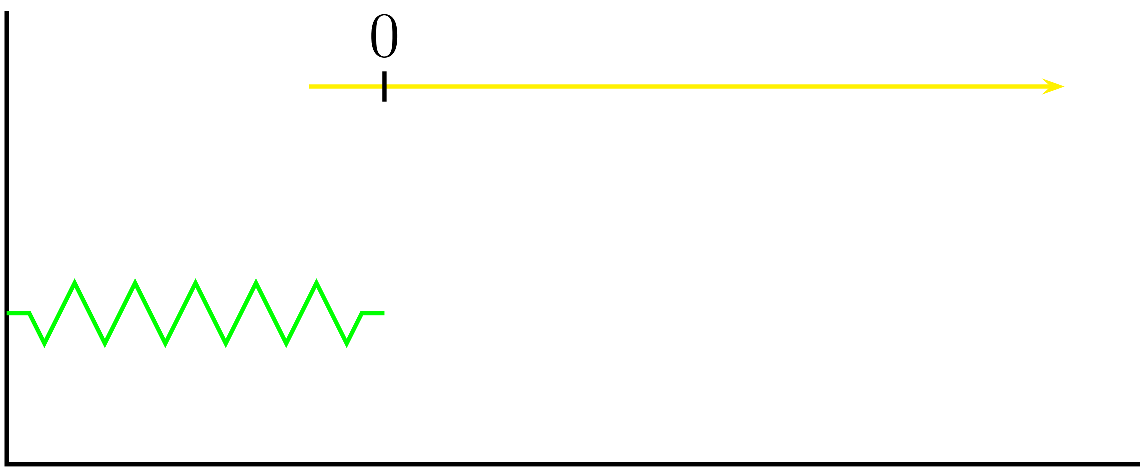

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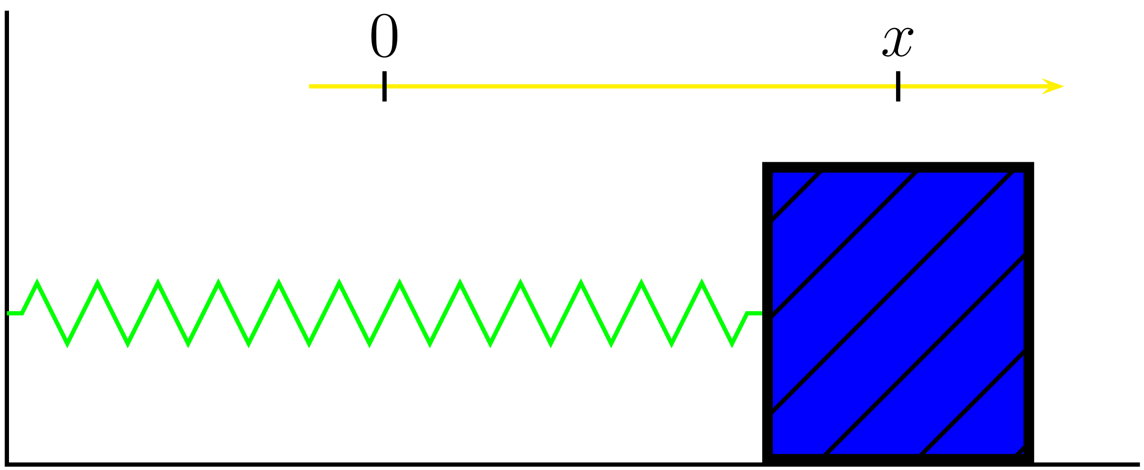

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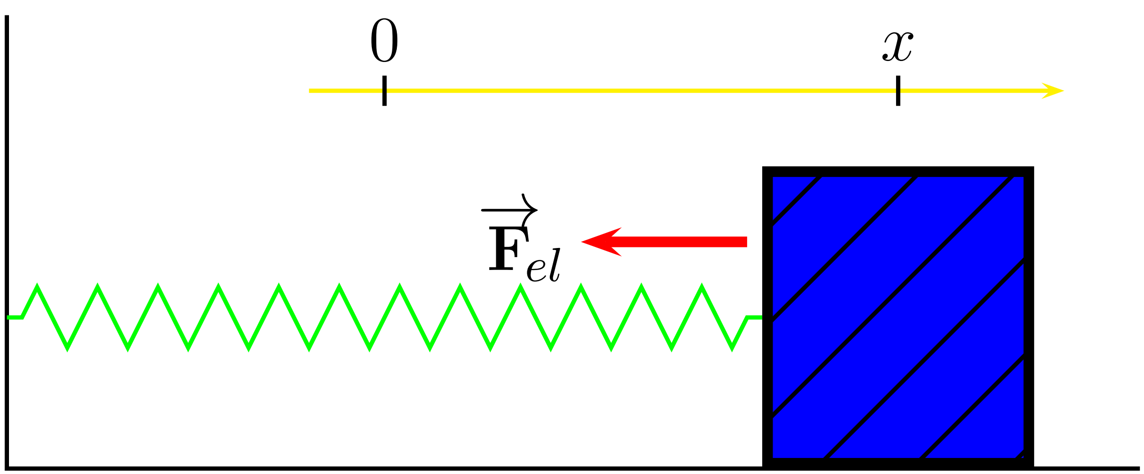

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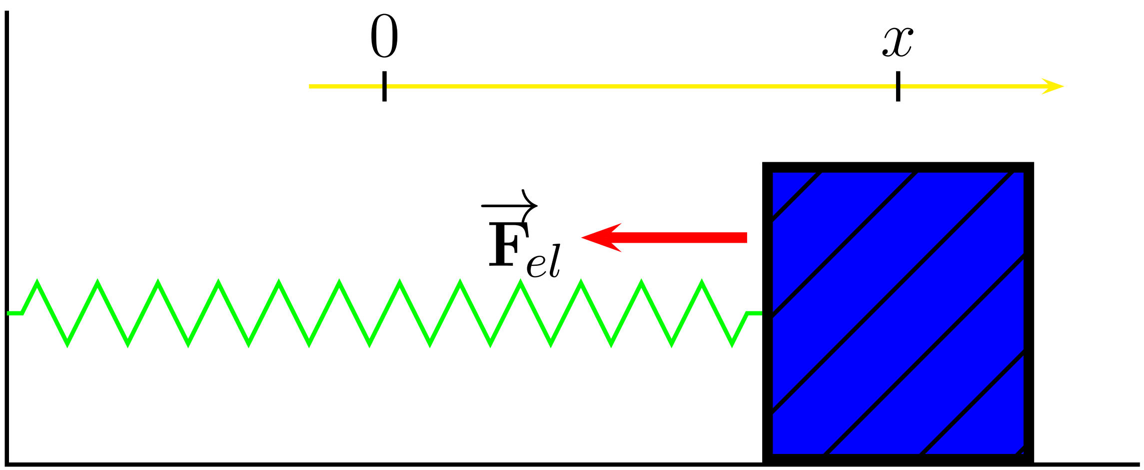
$$\sum \overrightarrow{\mathbf{F}} = M\overrightarrow{\mathbf{a}}$$



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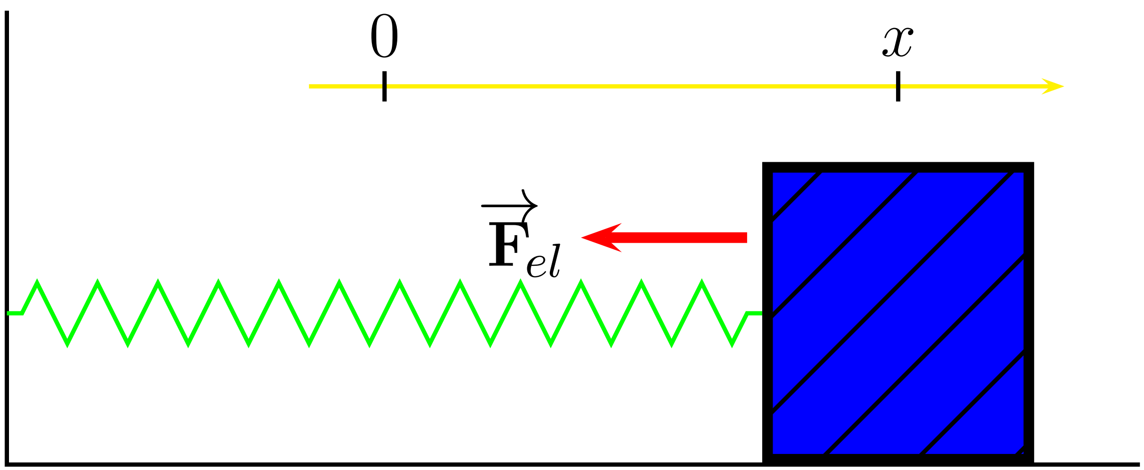

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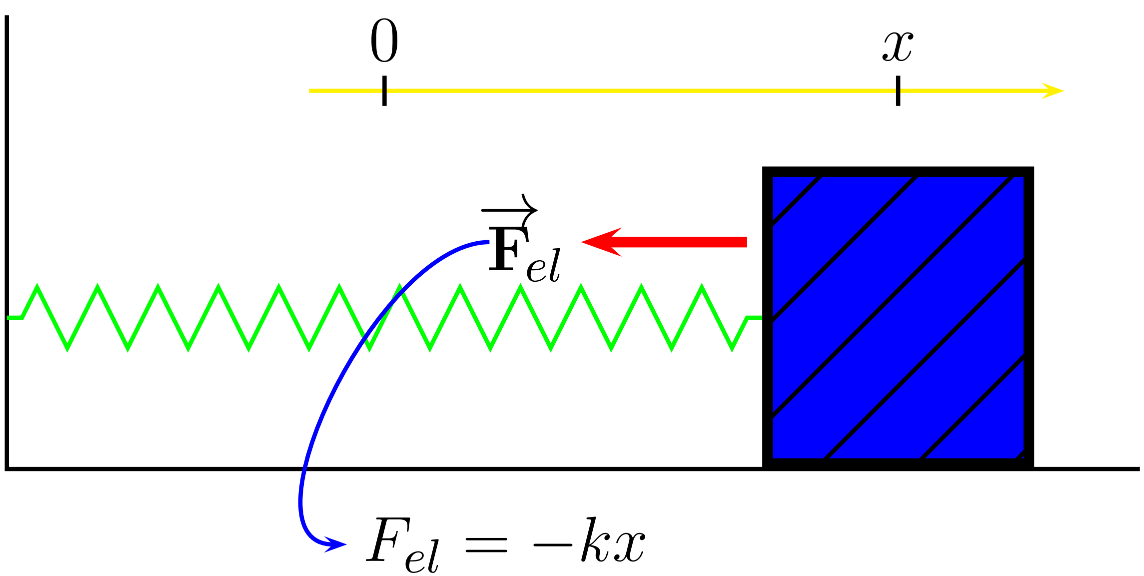

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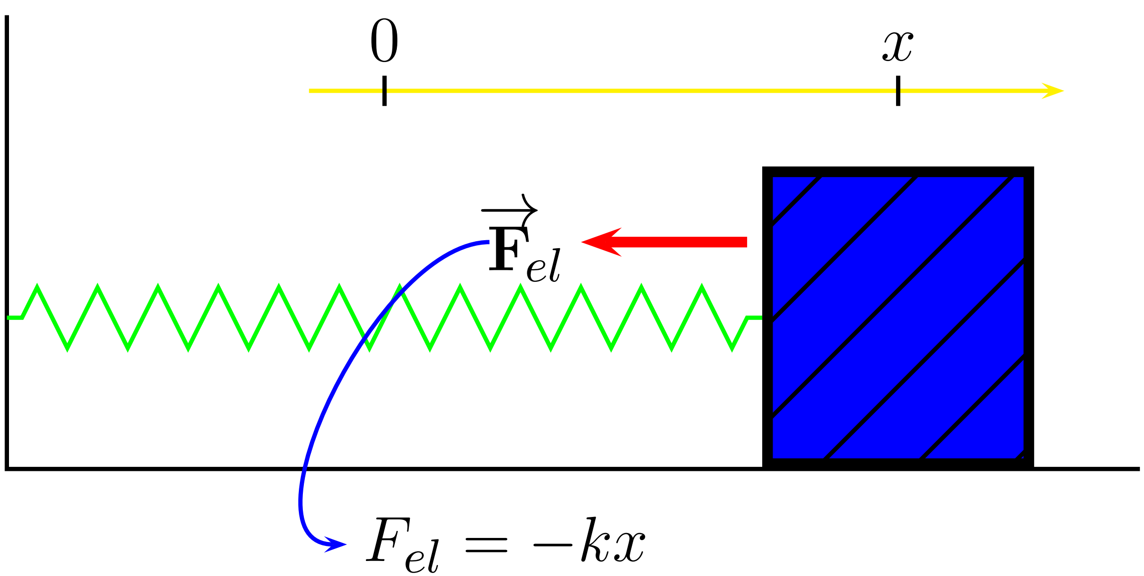

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$$-kx = Ma_x$$

Simple Harmonic Motion II

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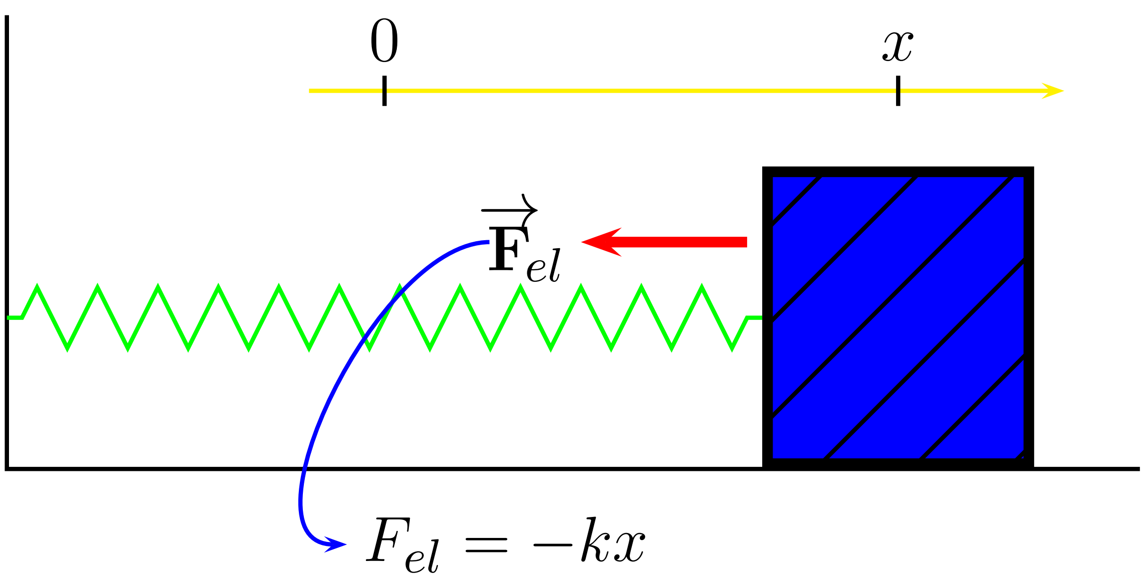

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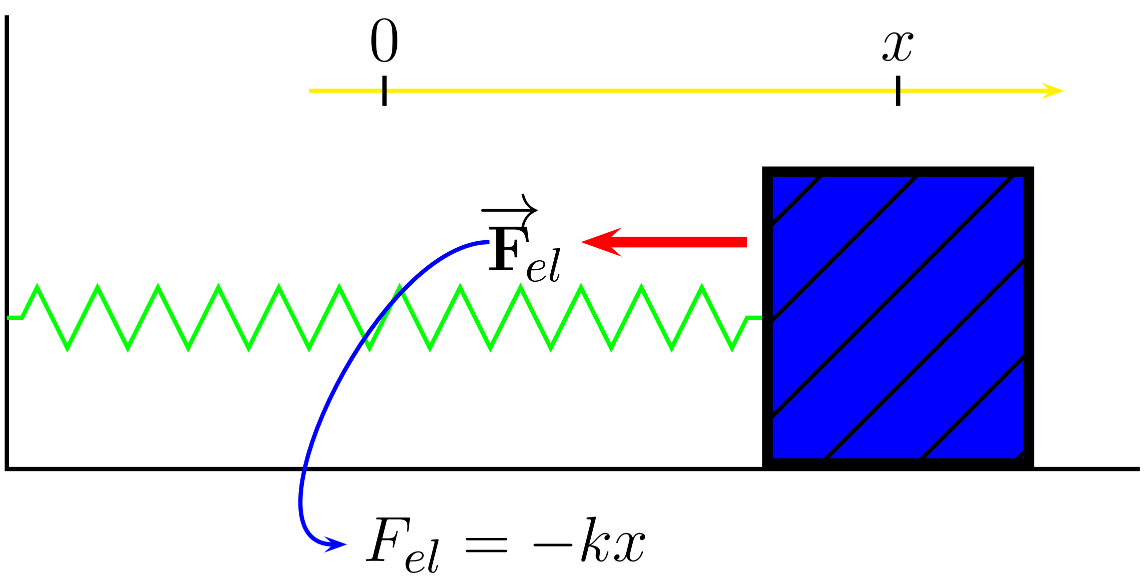

$$v_x = \frac{dx}{dt}$$

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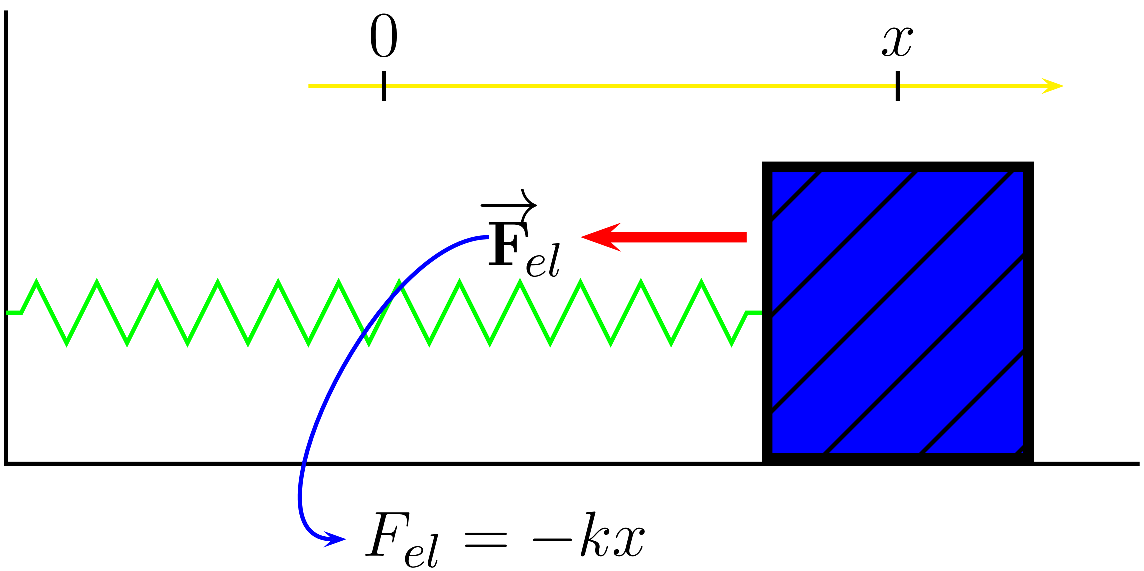

$$a_x = \frac{dv_x}{dt}$$

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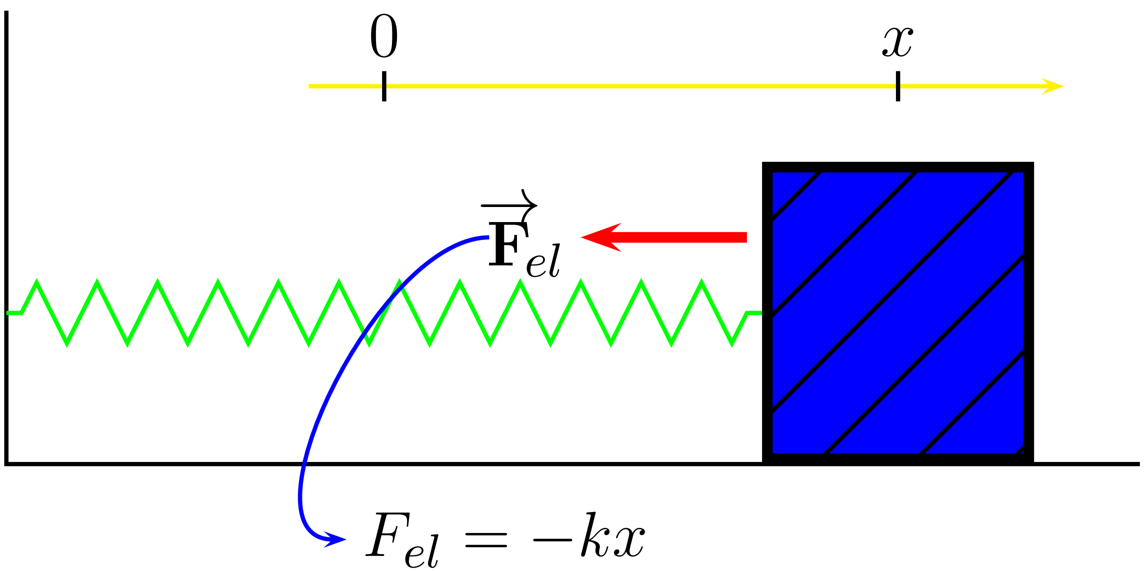

$$a_x = \frac{d^2x}{dt^2}$$

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Simple Harmonic Motion III

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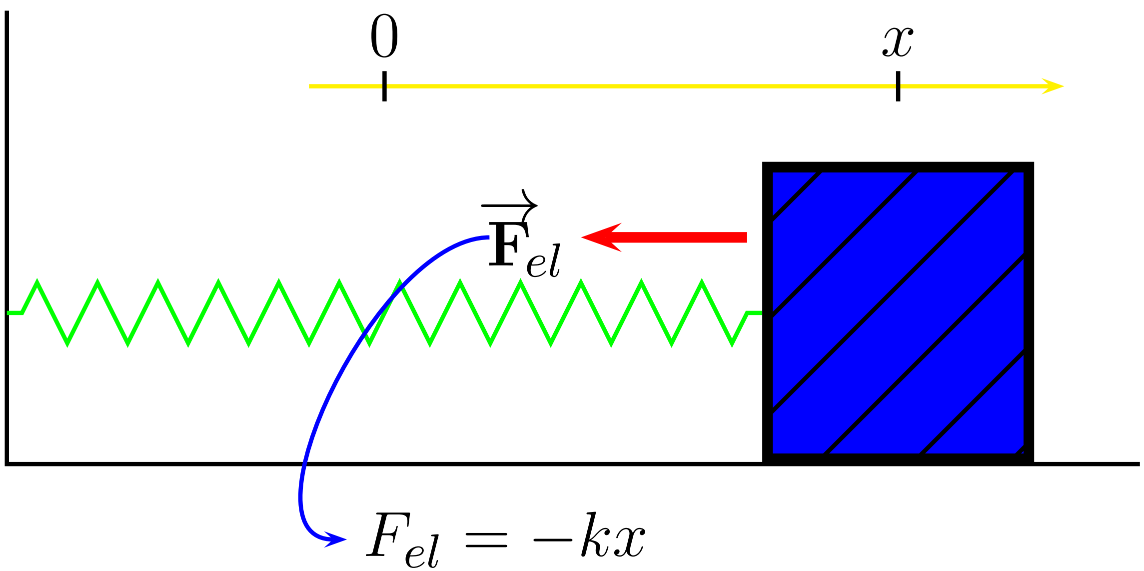
$$-kx = M\frac{d^2x}{dt^2}$$



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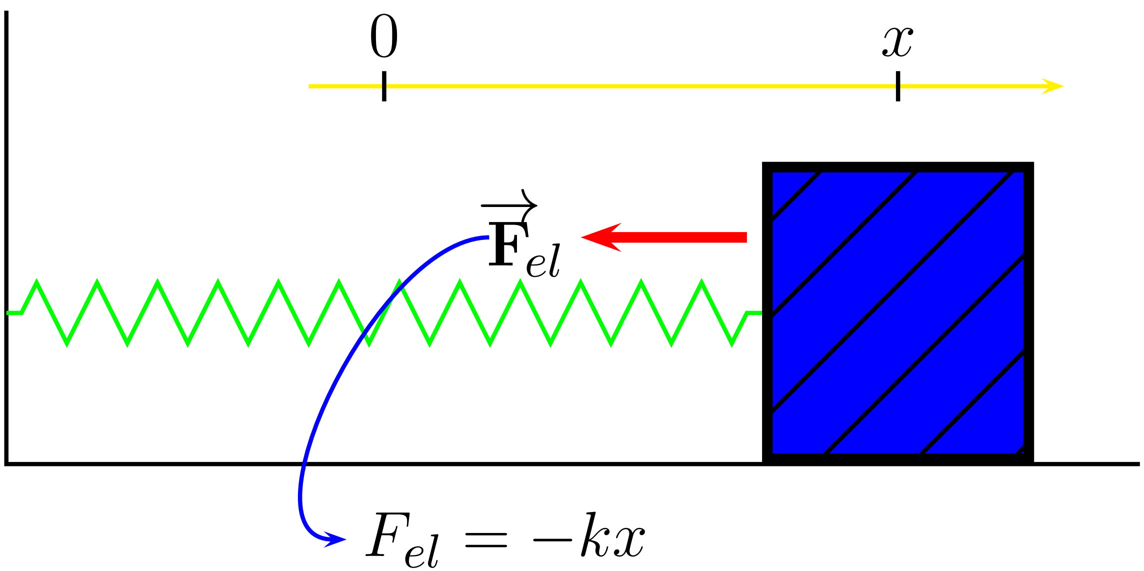

$$-kx = M\frac{d^2x}{dt^2}$$

$$\boxed{\frac{d^2x}{dt^2} = -\left(\frac{k}{M}\right)x}$$

Differential Equation for SHM

Simple Harmonic Motion IV

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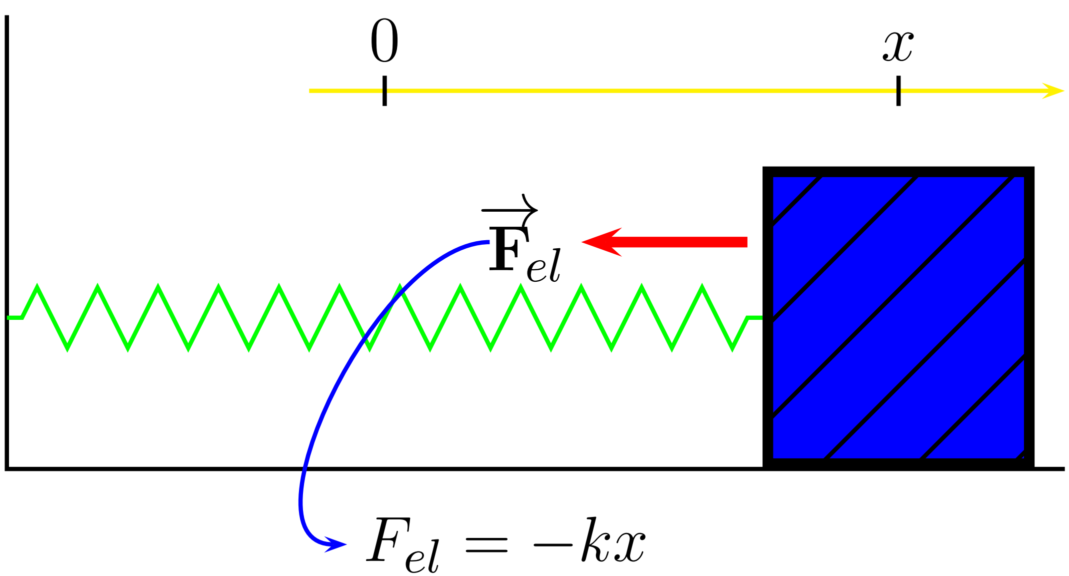

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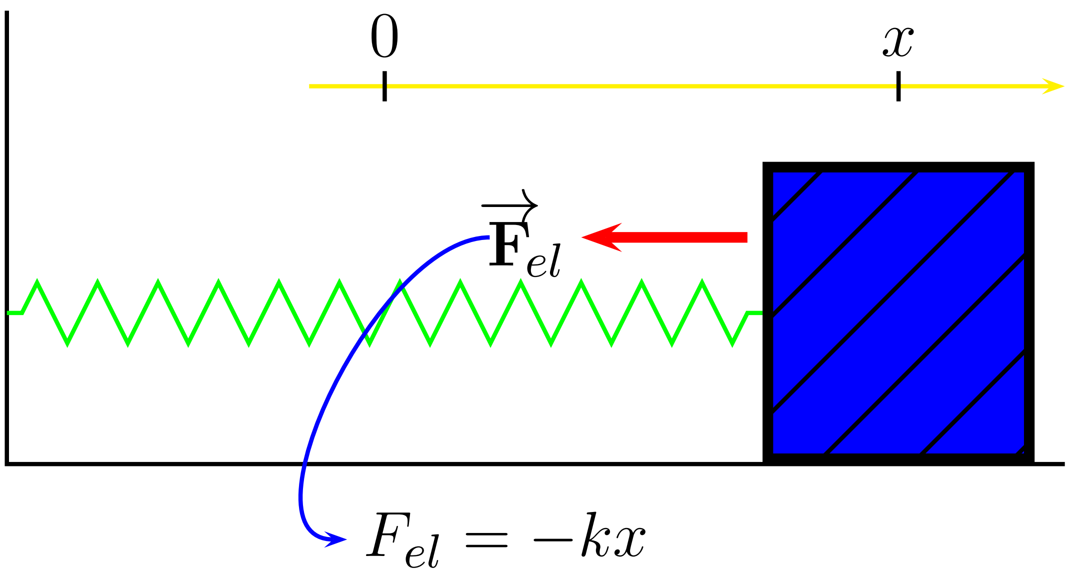

In Calculus: $f'' = -cf$

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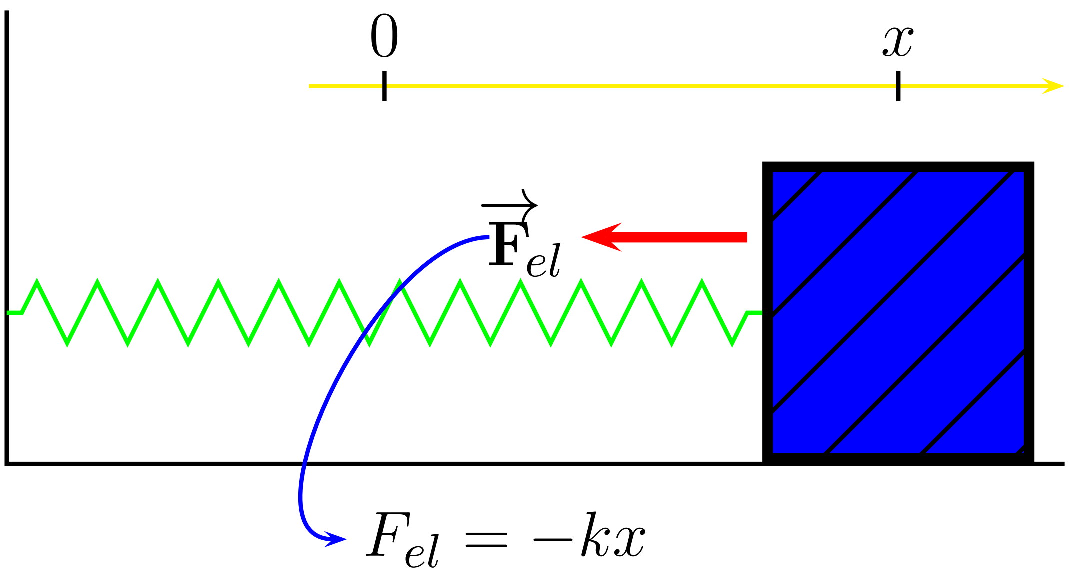

In Calculus: $f'' = -cf$

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

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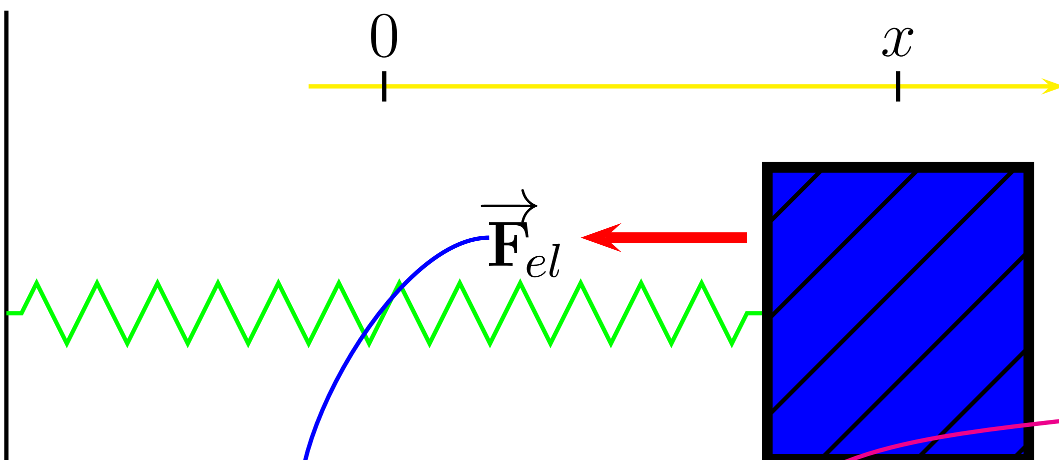

$F_{el} = -kx$

Amplitude

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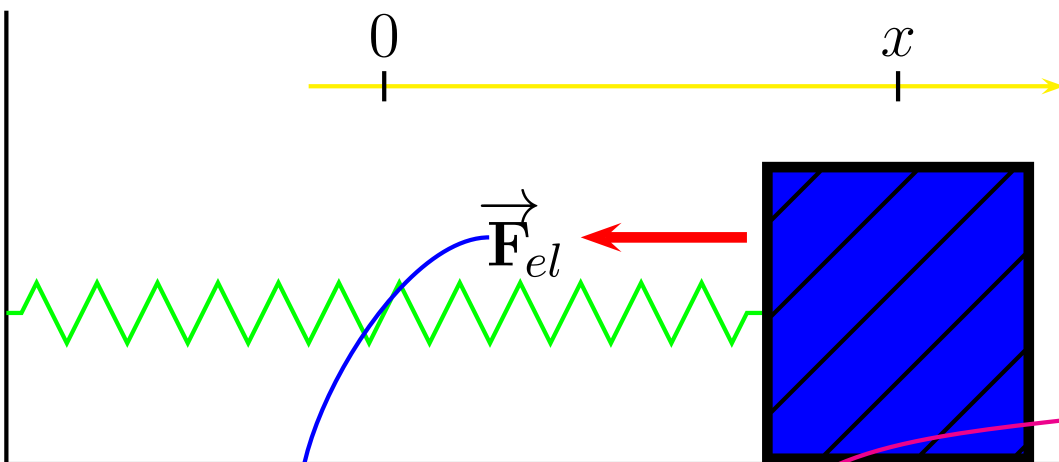

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Phase Angle

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Amplitude

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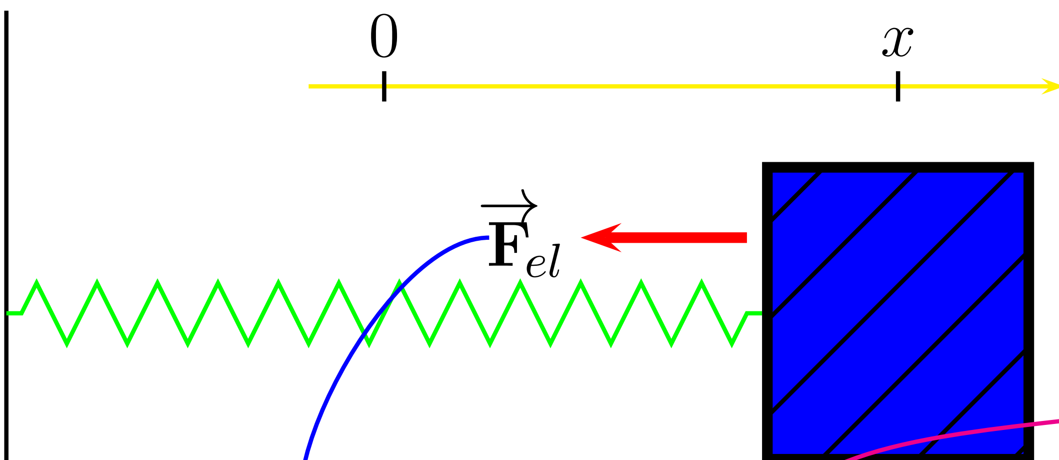

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Phase Angle

Angular frequency,

$$\omega = 2\pi f = \frac{2\pi}{T}$$

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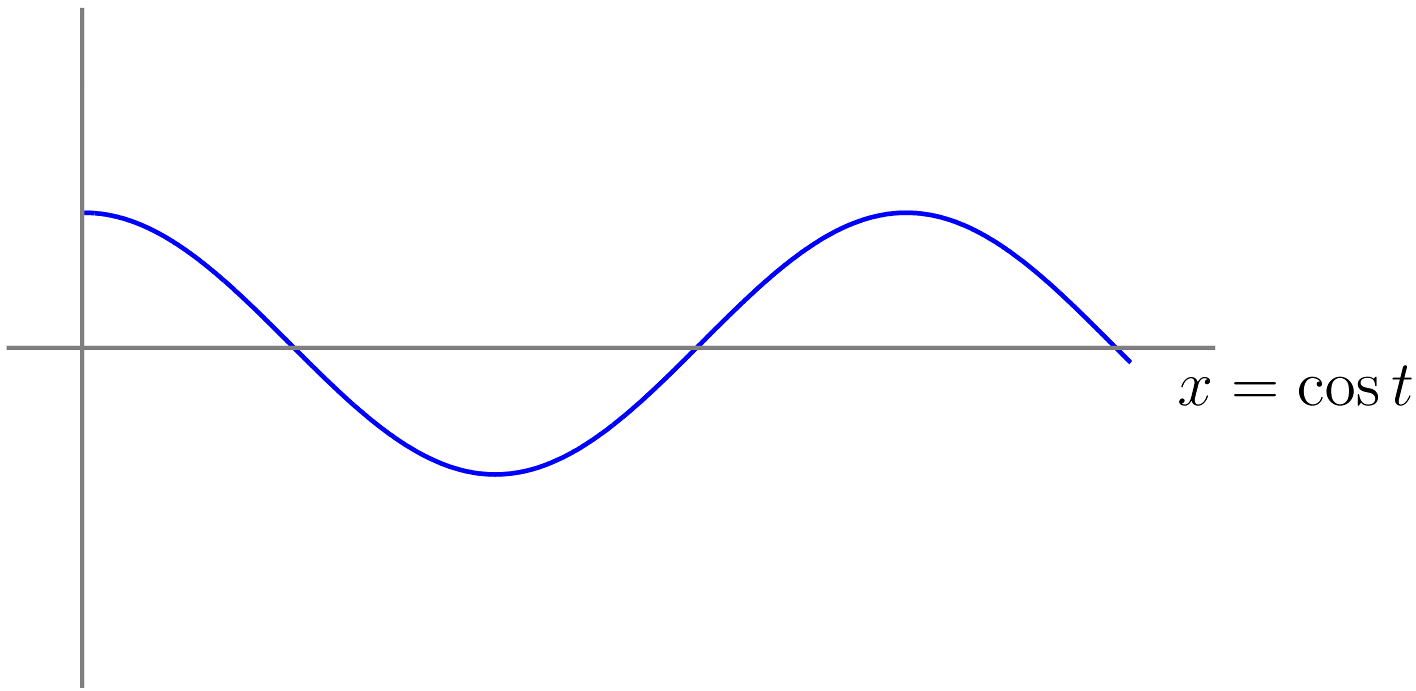

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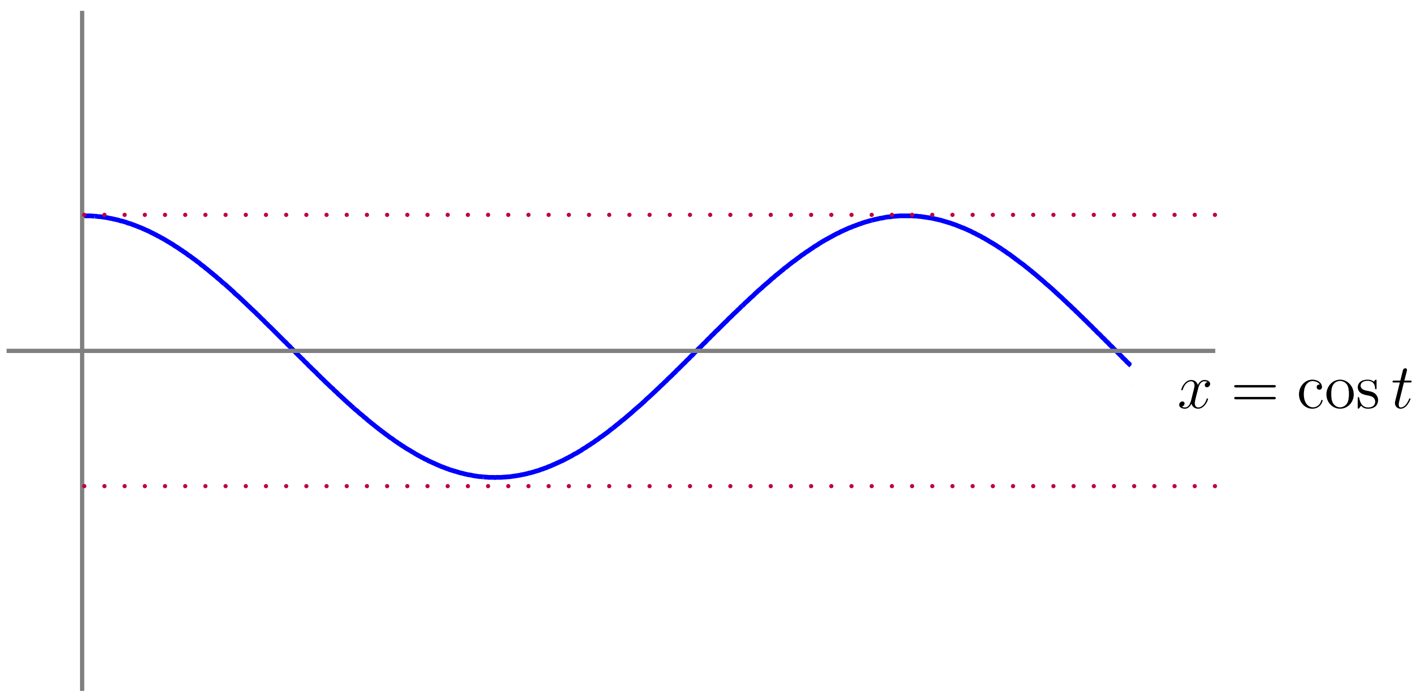

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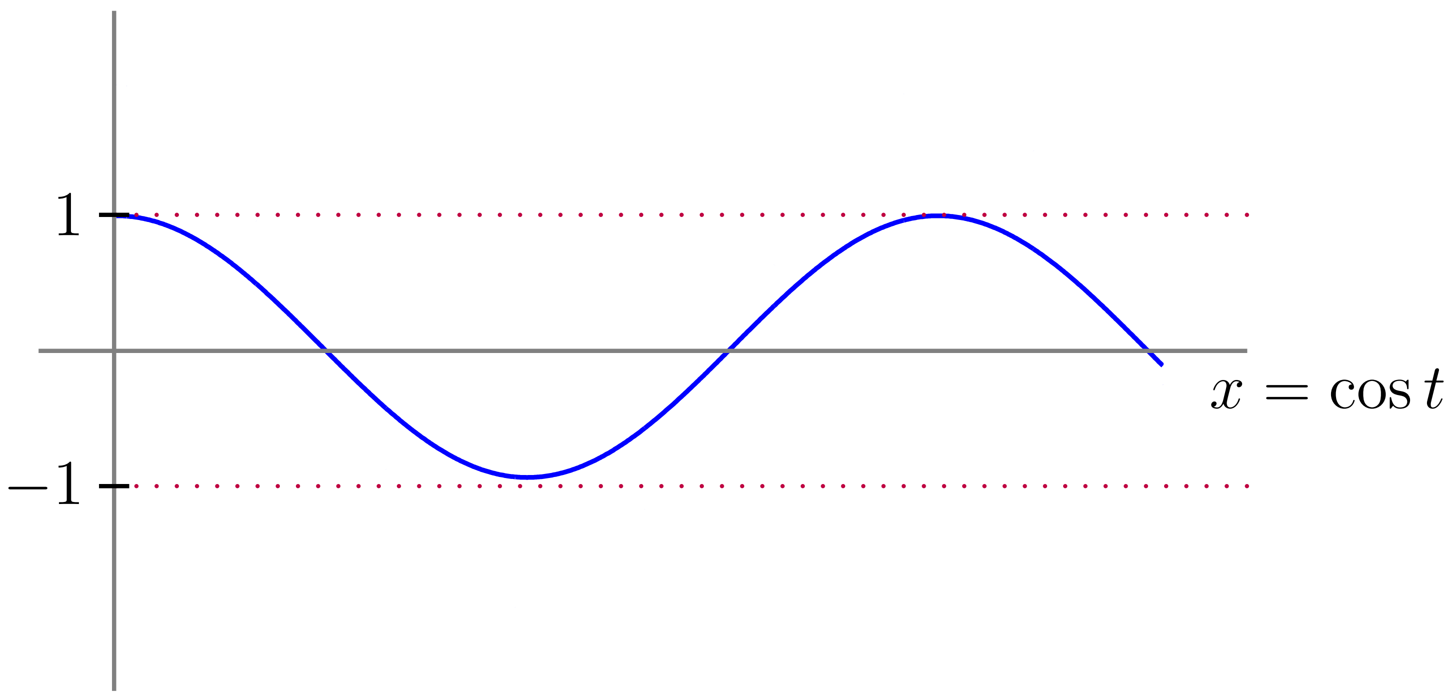

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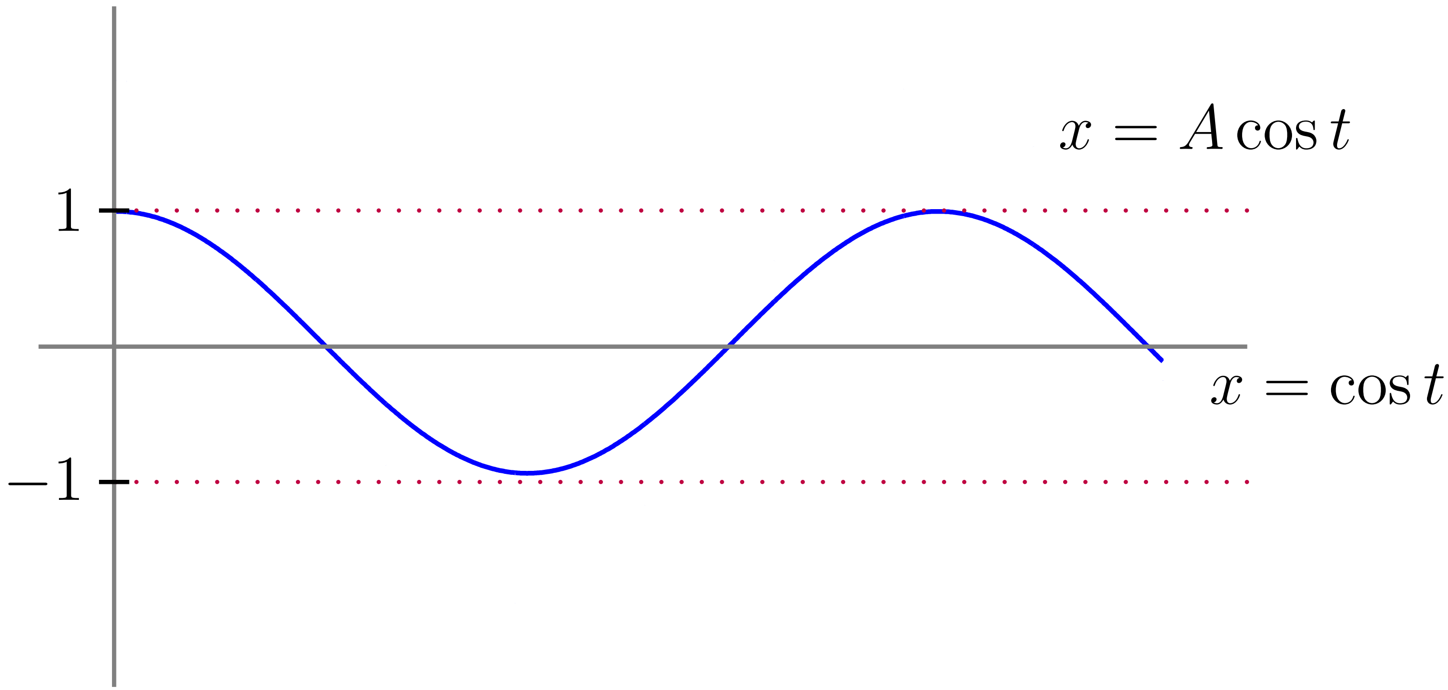

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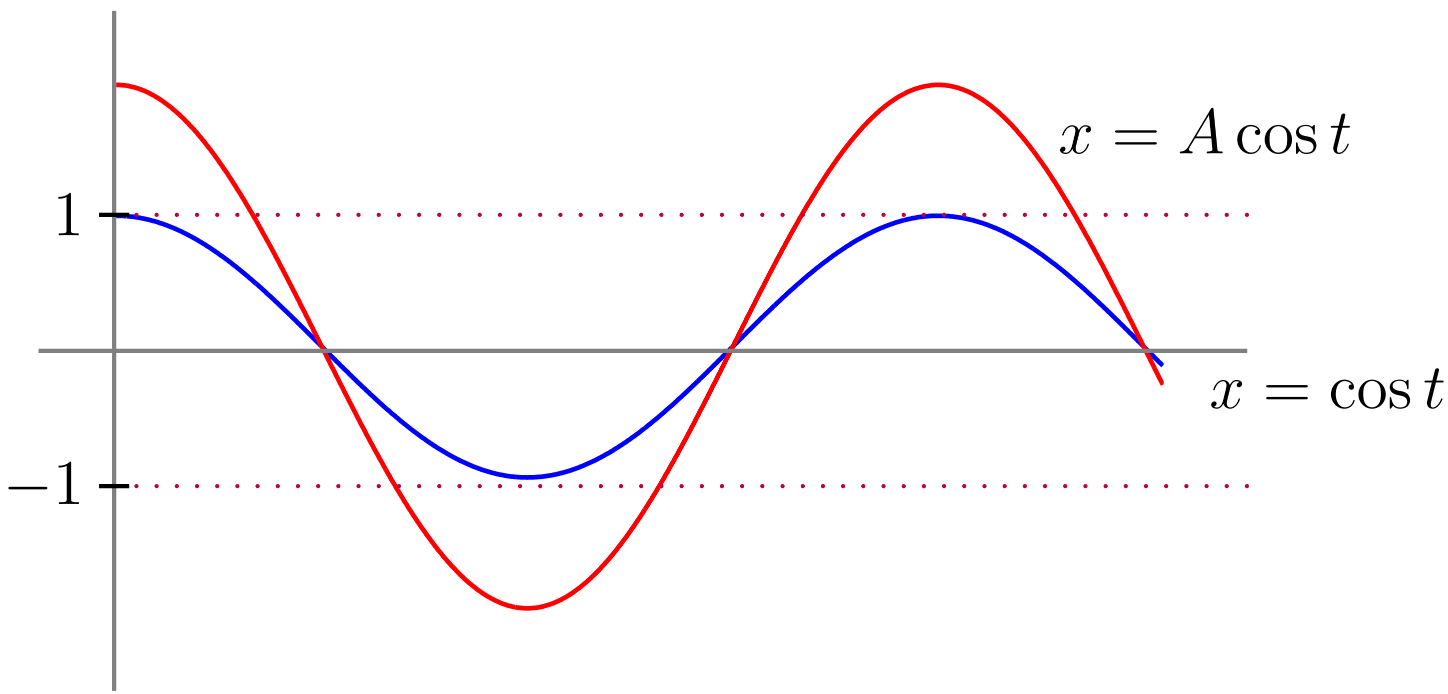

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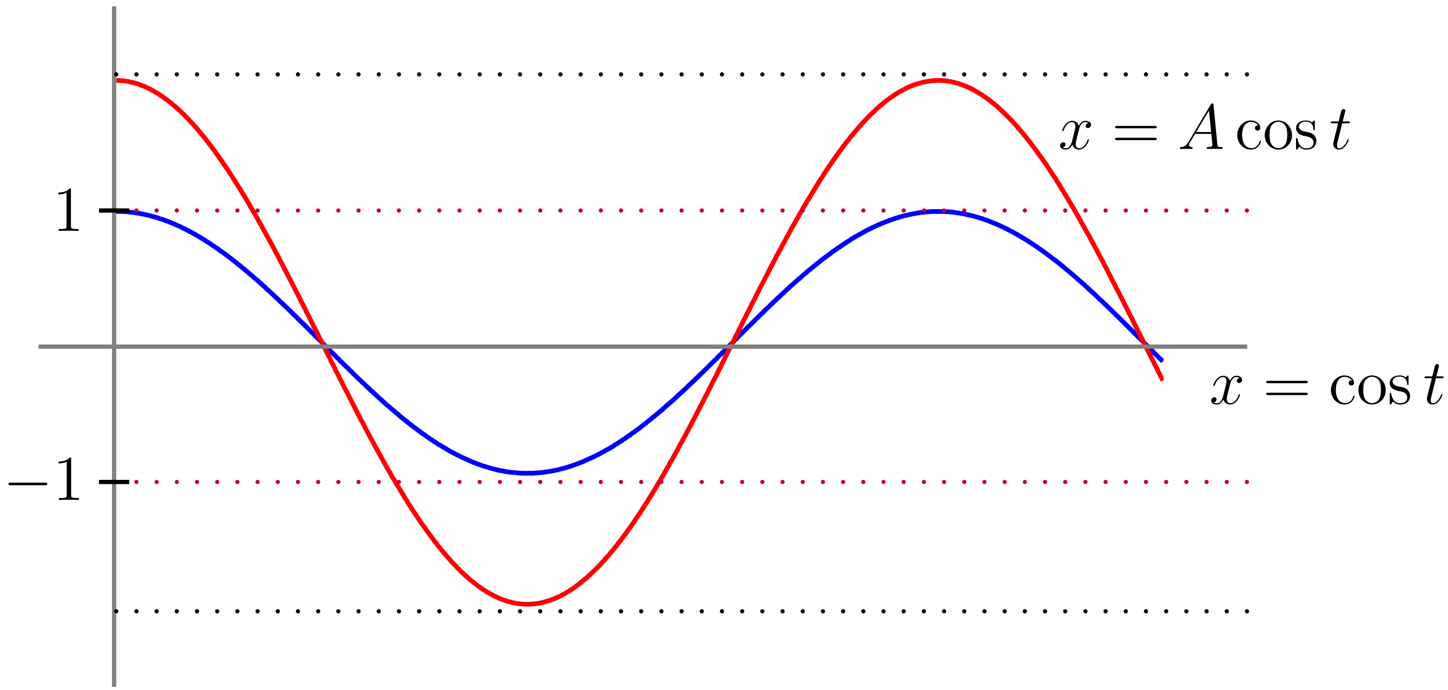

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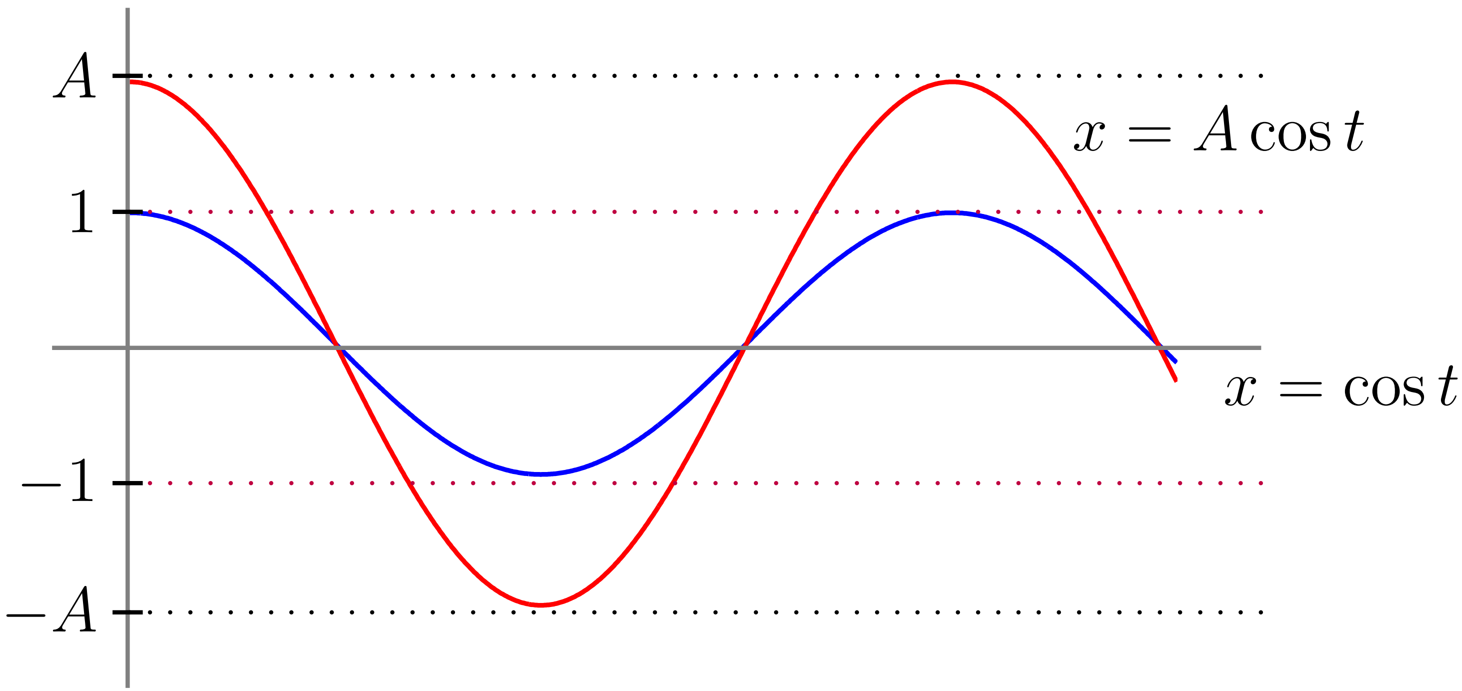

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Phase Angle - ϕ, Units: rad. Shifts the Cosine to start wherever needed.

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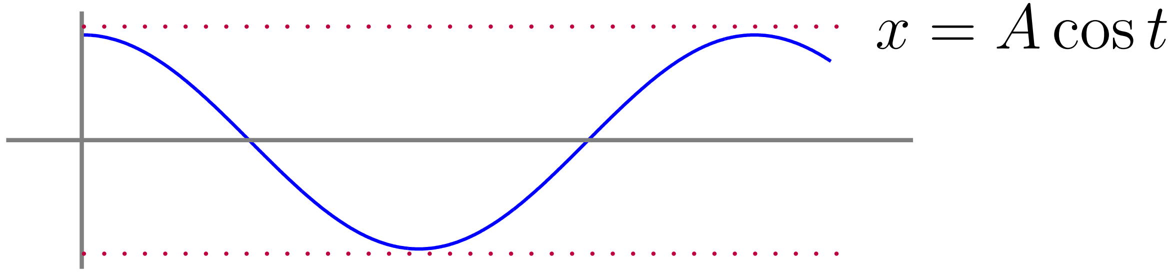

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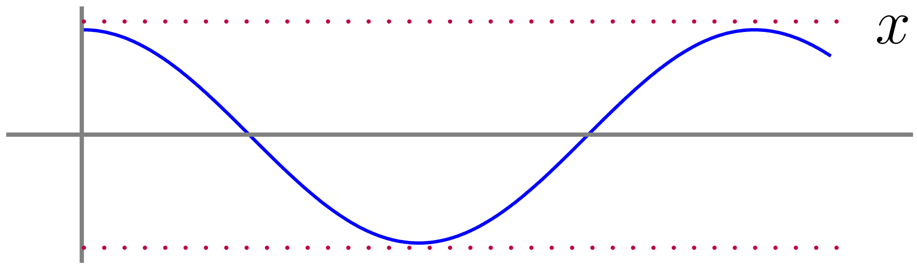

$$x = A\cos t$$

$$x = A\cos\left(t + \frac{\pi}{4}\right)$$

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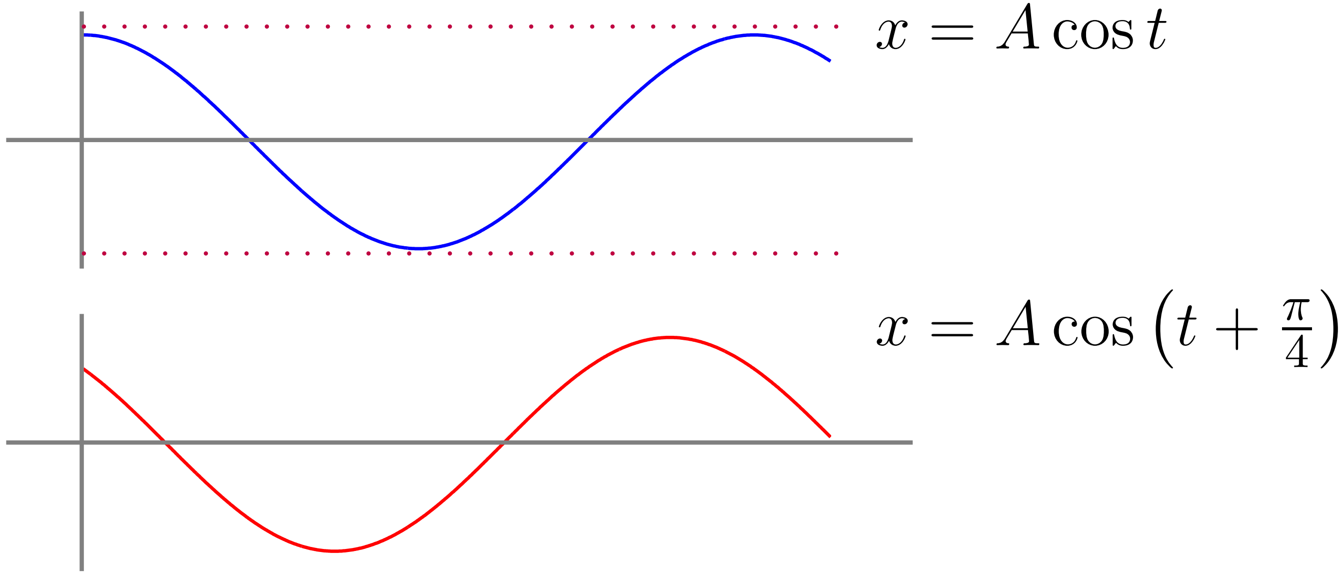

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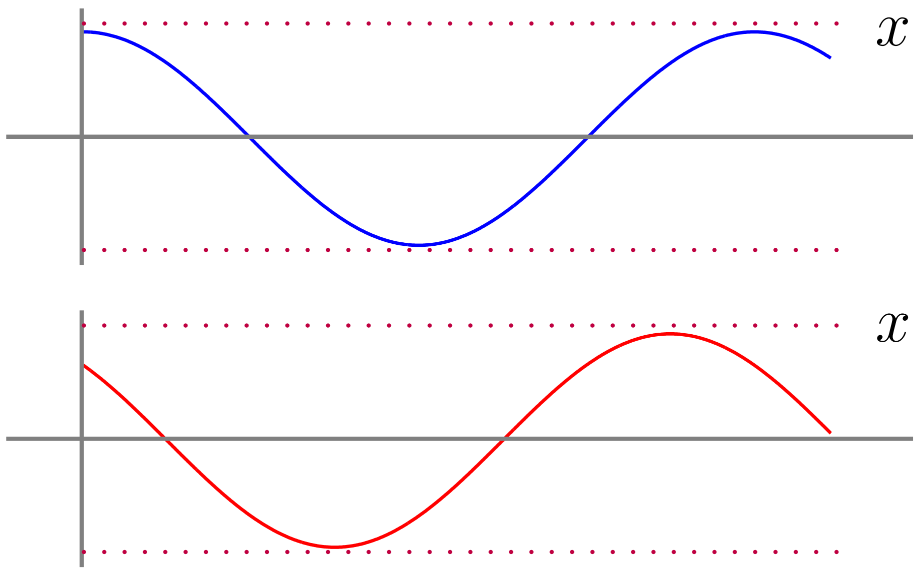

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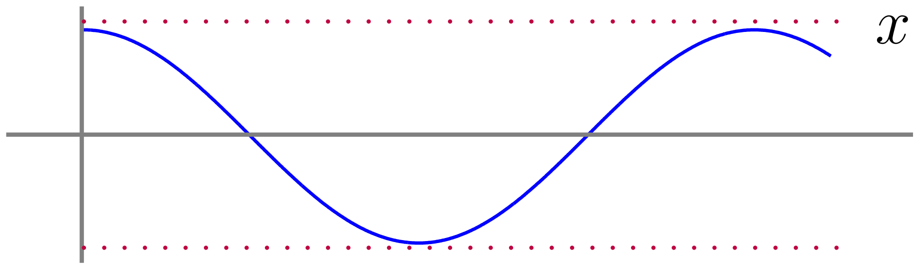

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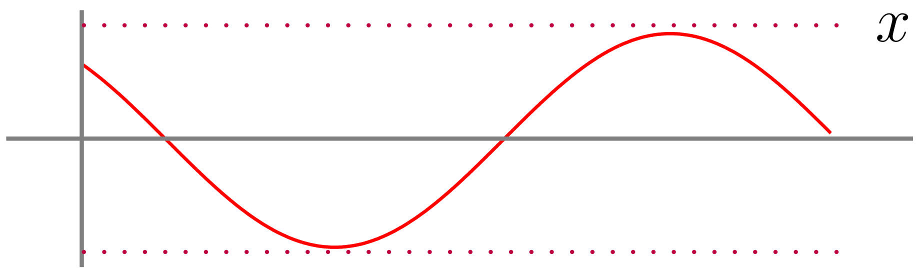

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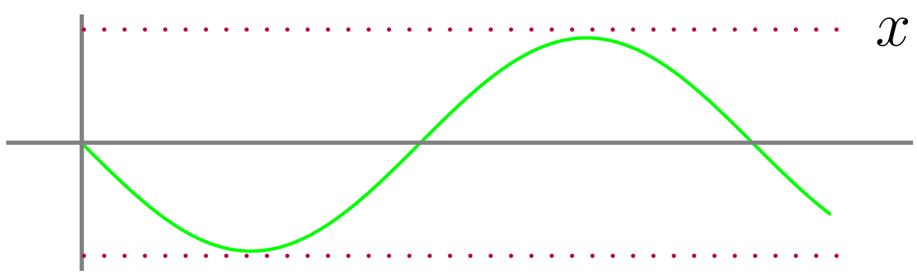

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Phase Angle

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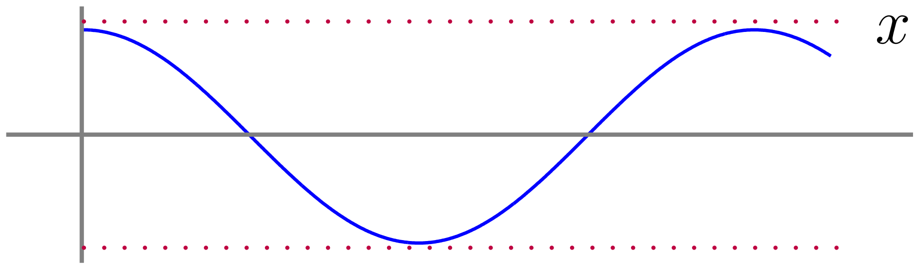

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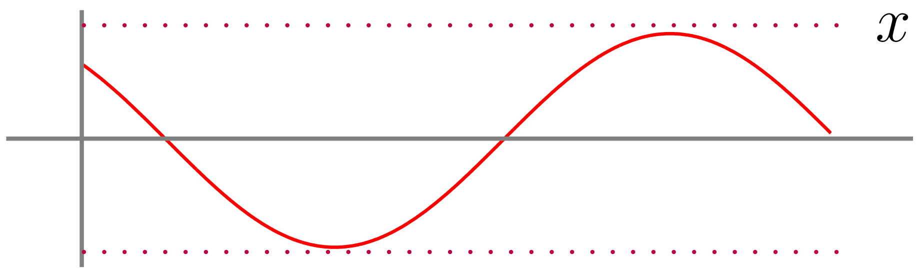

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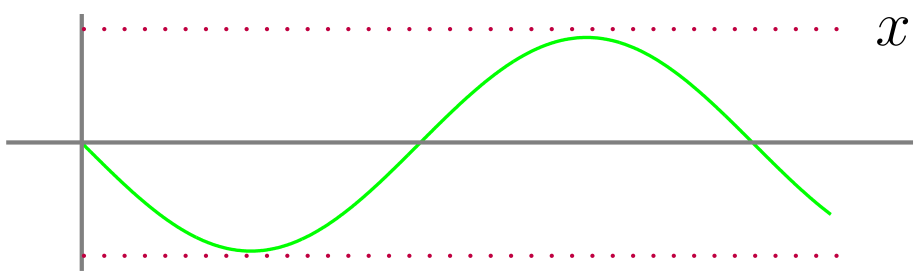

$$x = A\cos\left(t + \frac{\pi}{2}\right)$$
$$= -\sin t$$

Angular Frequency

Angular Frequency - $\omega = 2\pi f = \dfrac{2\pi}{T}$ Units: rad/s

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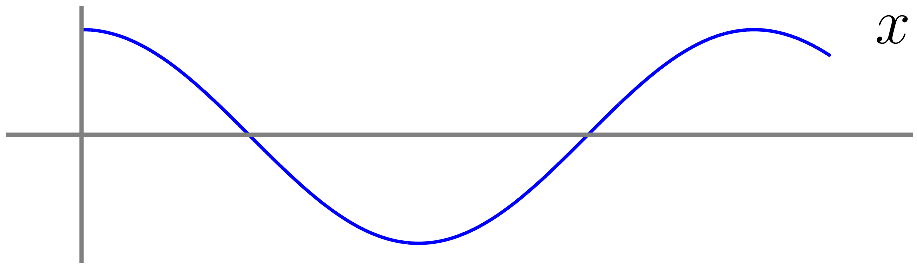

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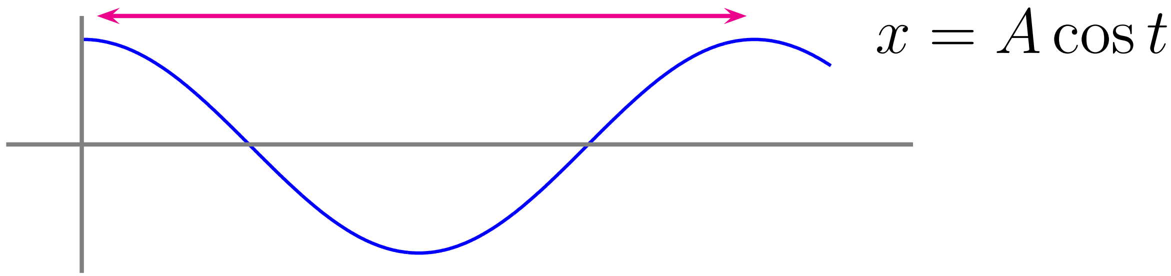

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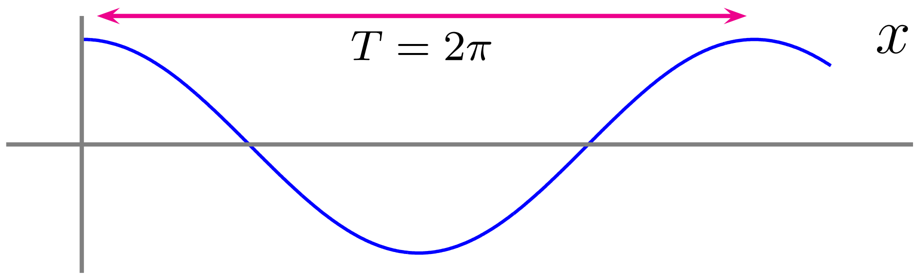

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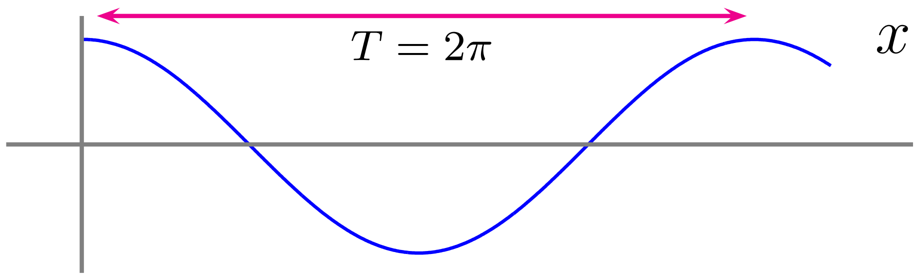

$x = A\cos t$

$x = A\cos(2\pi t)$

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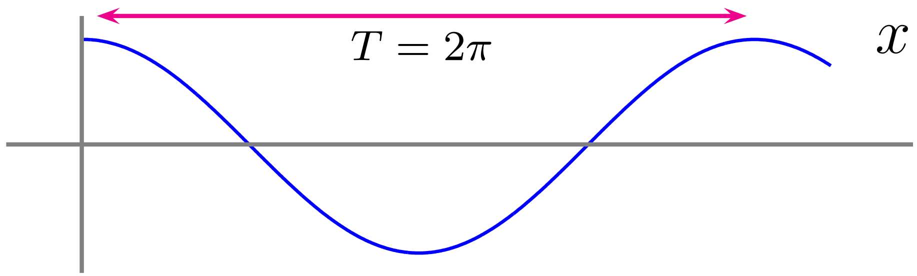

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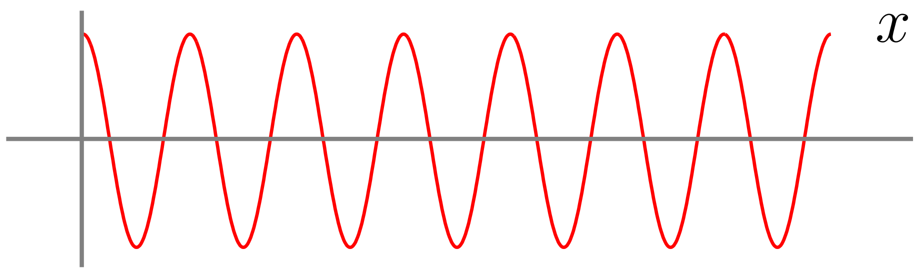

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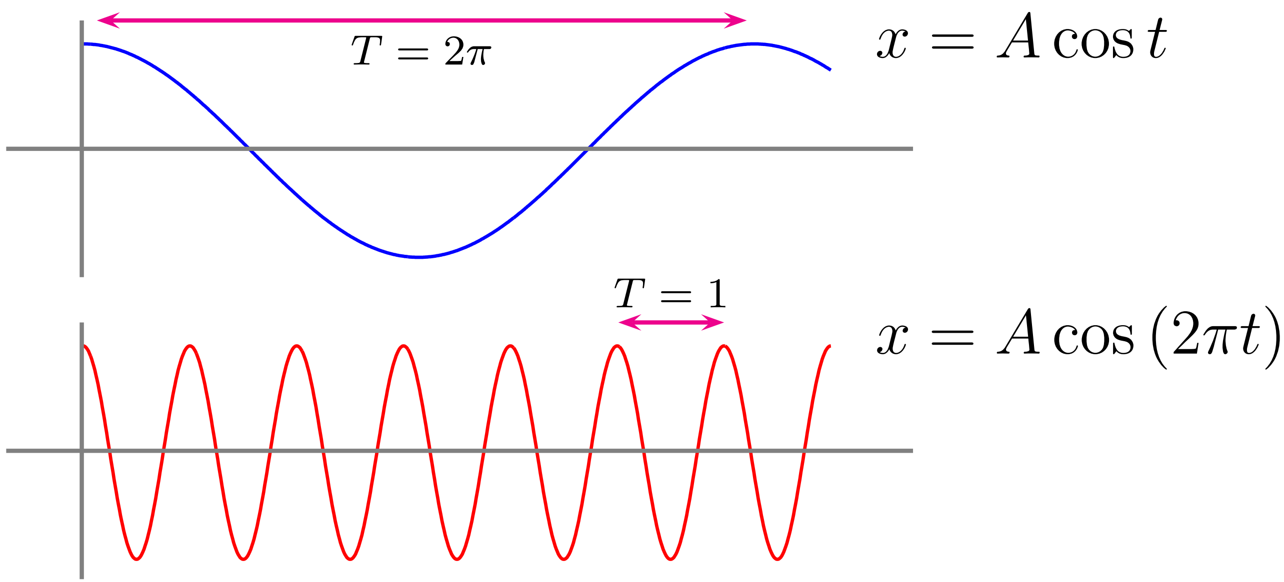

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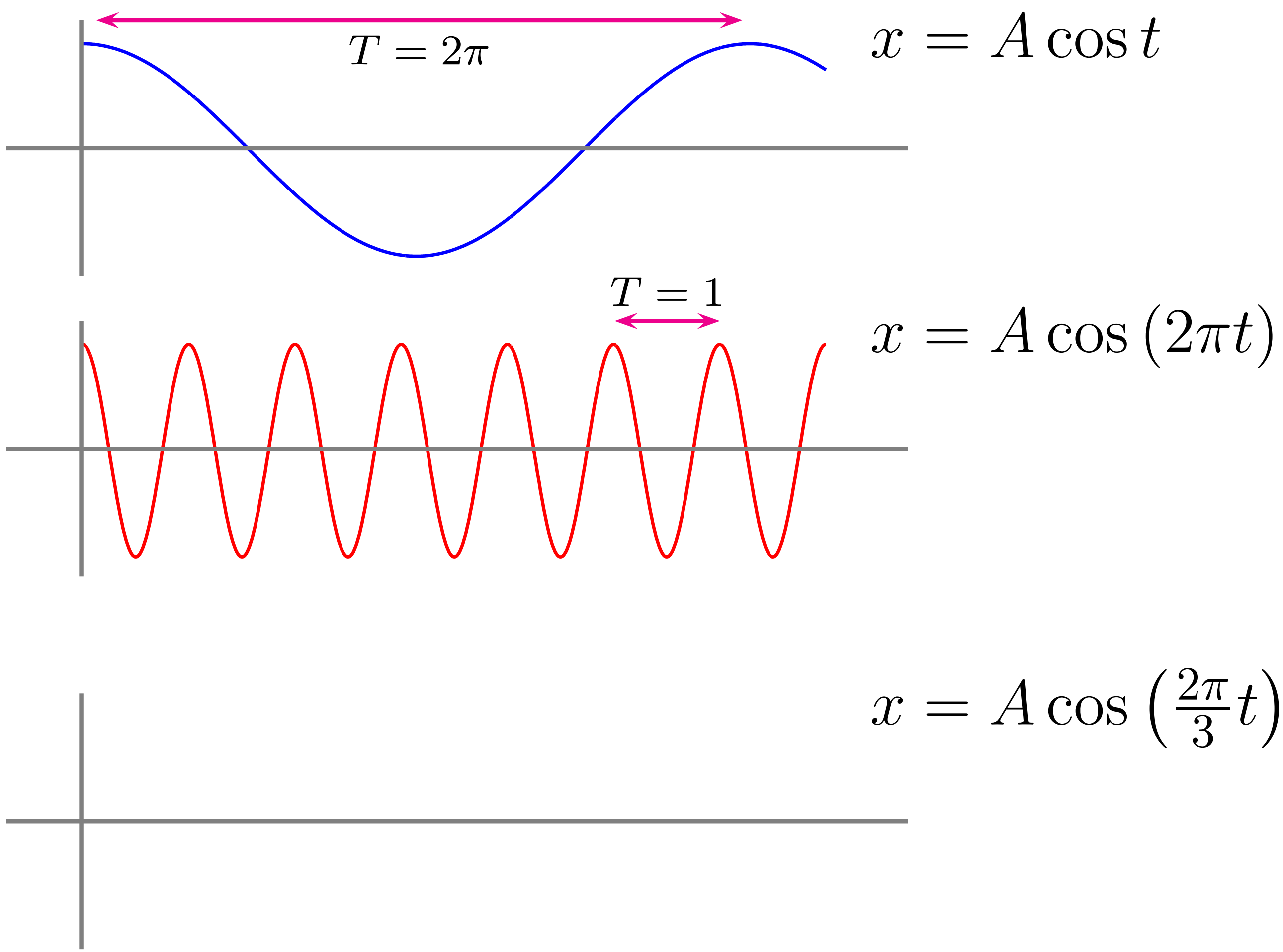

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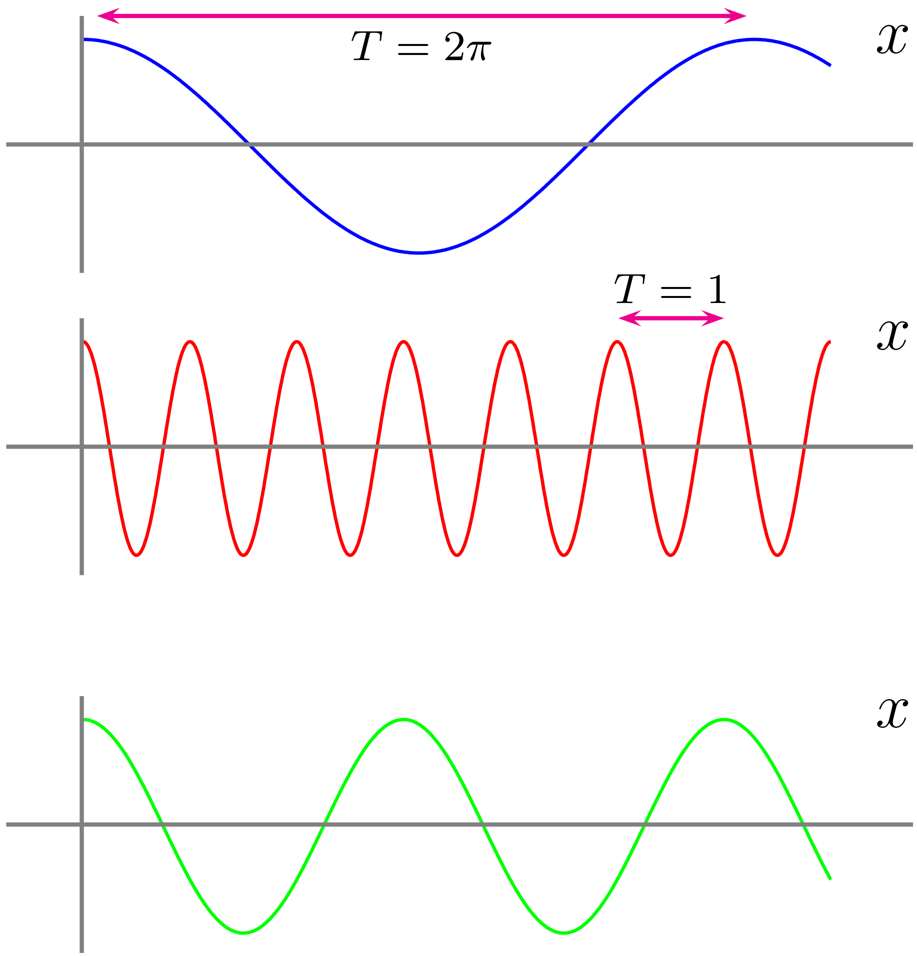

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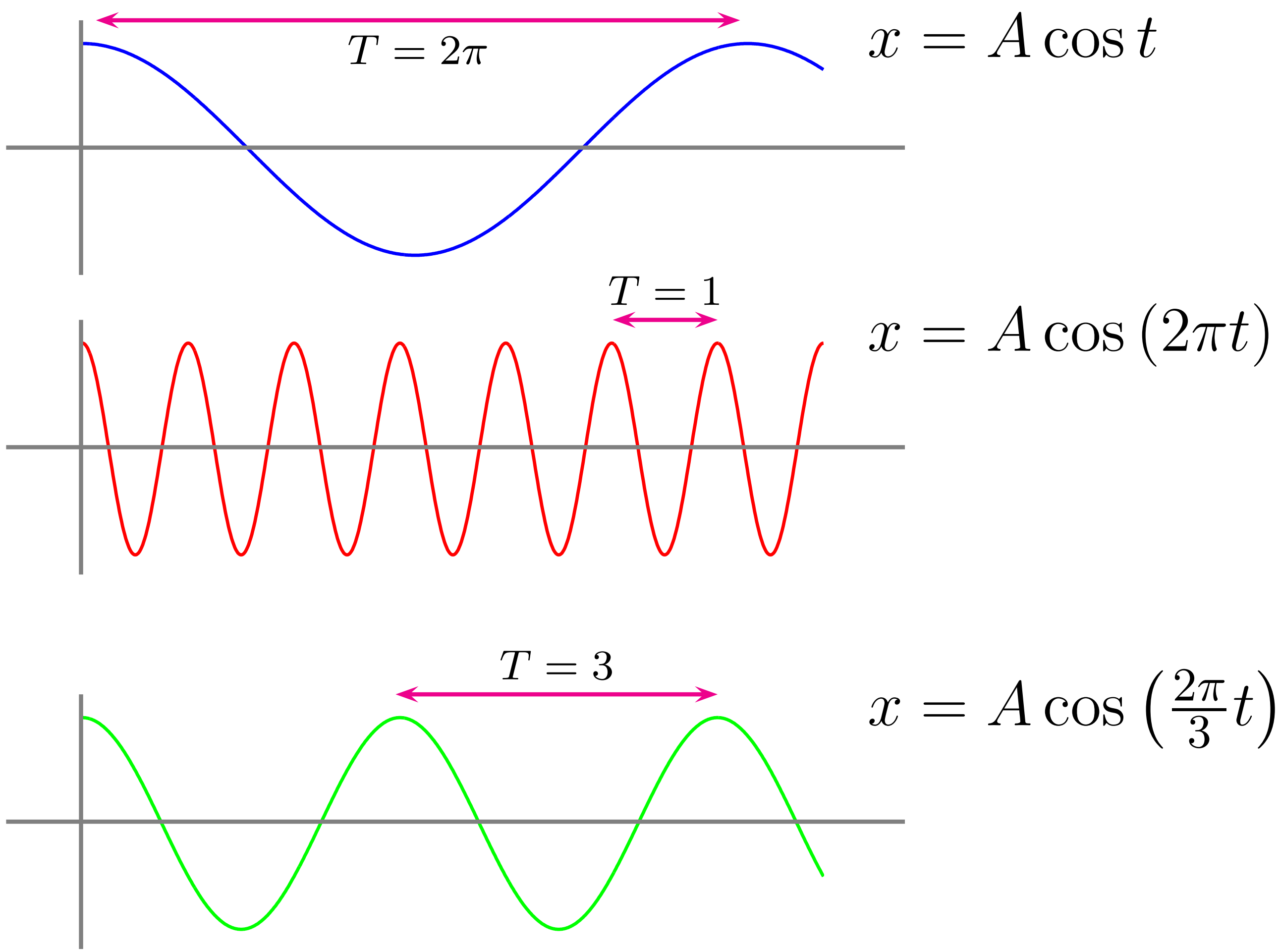

General Solution

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

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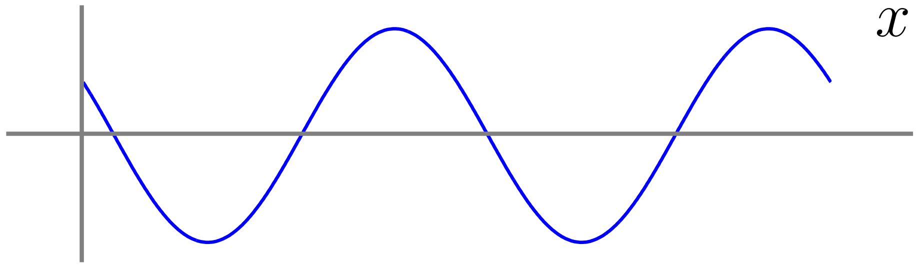

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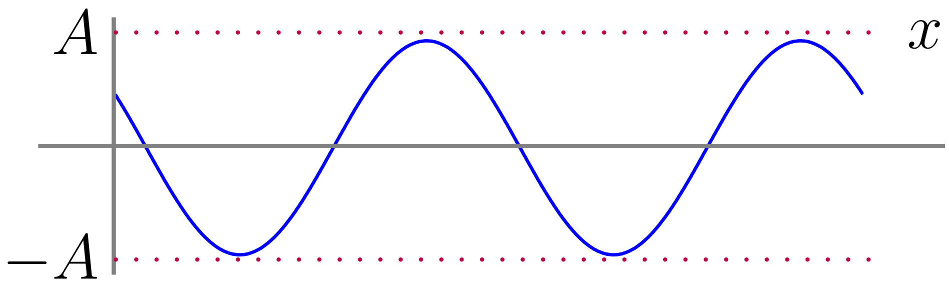
General Solution



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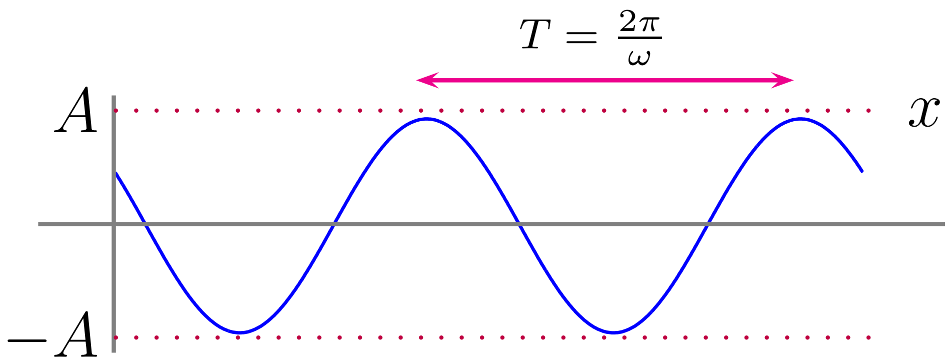

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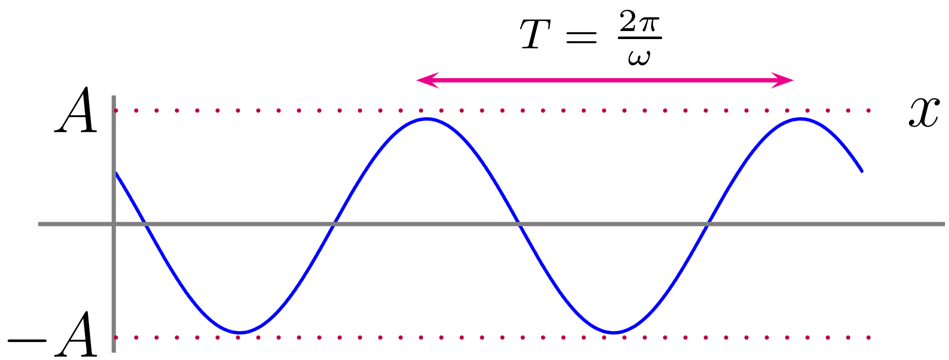

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Differential Equation for SHM: $$\frac{d^2x}{dt^2} = -\left(\frac{k}{M}\right)x$$

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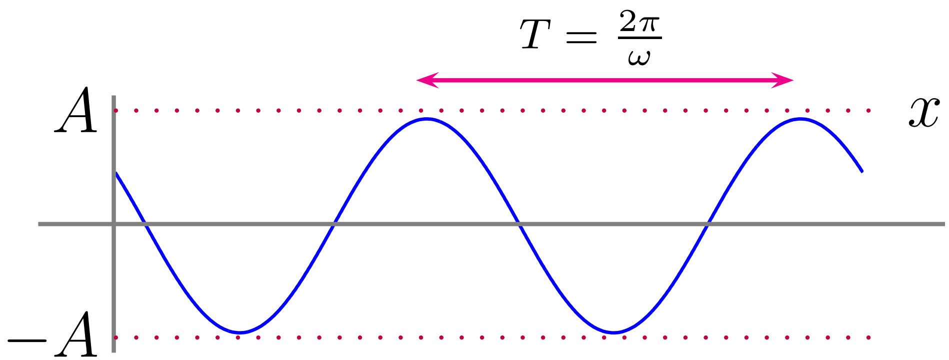

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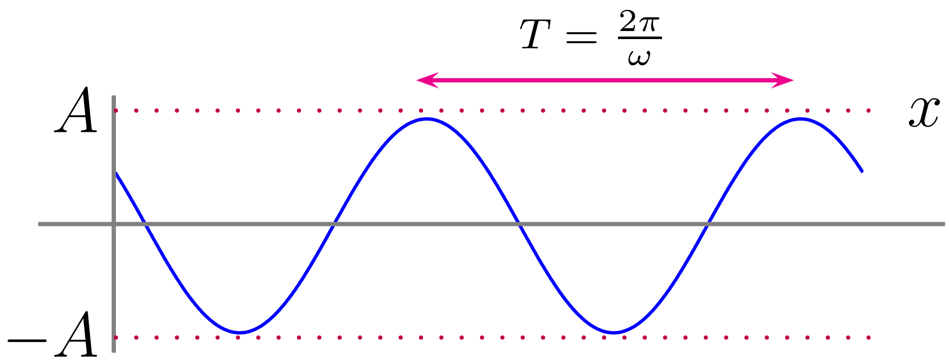

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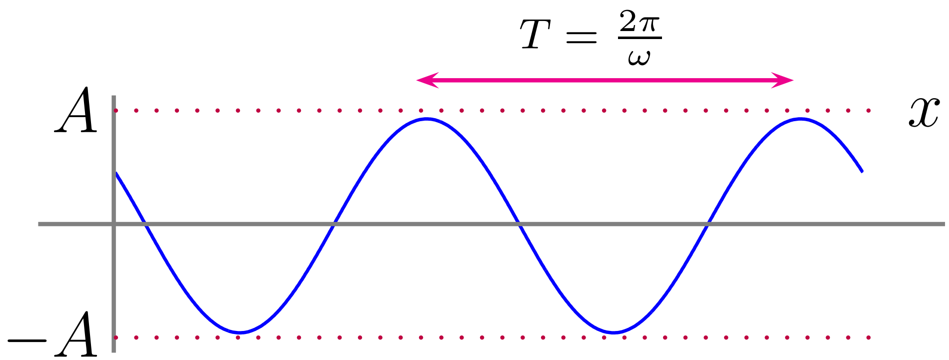

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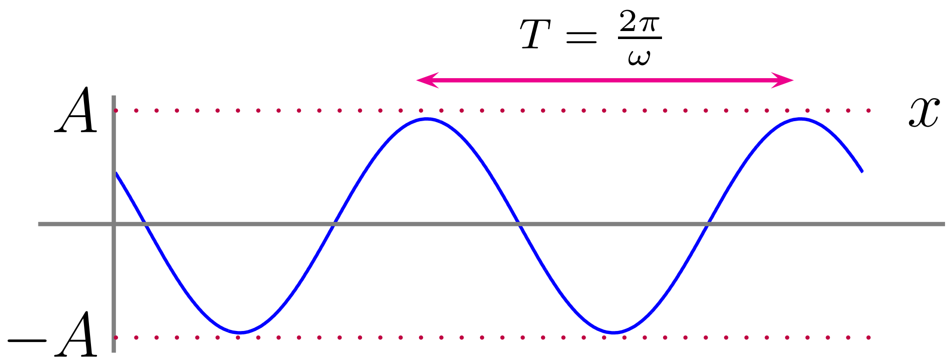

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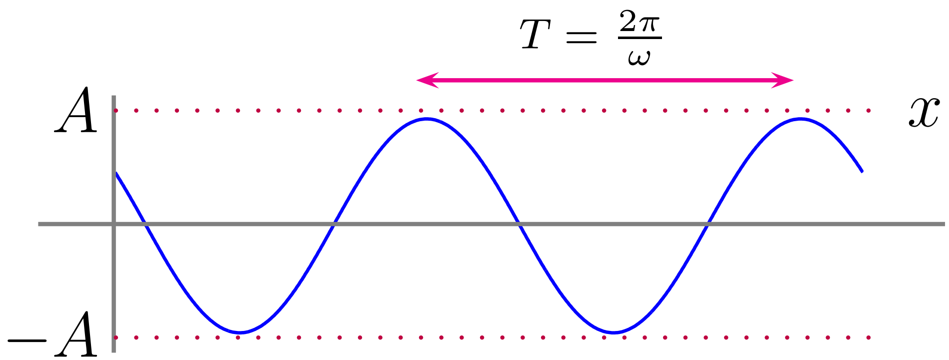

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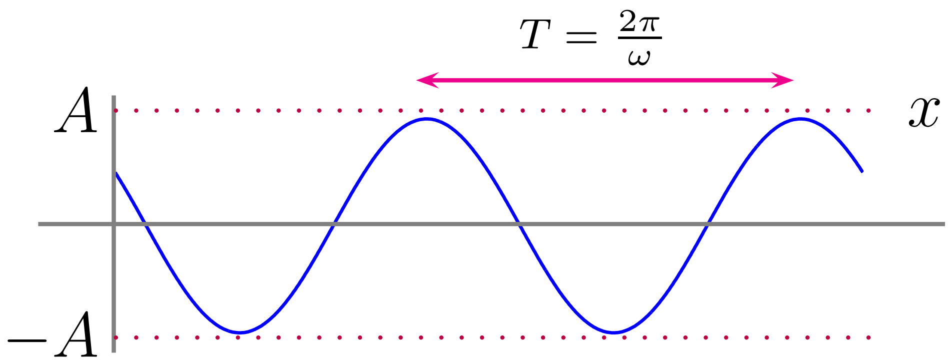

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$$\omega^2 = \left(\frac{k}{M}\right)$$

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

Pendulum

Under the right conditions, a pendulum will undergo simple harmonic motion.

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Simple Pendulum - Massless connector

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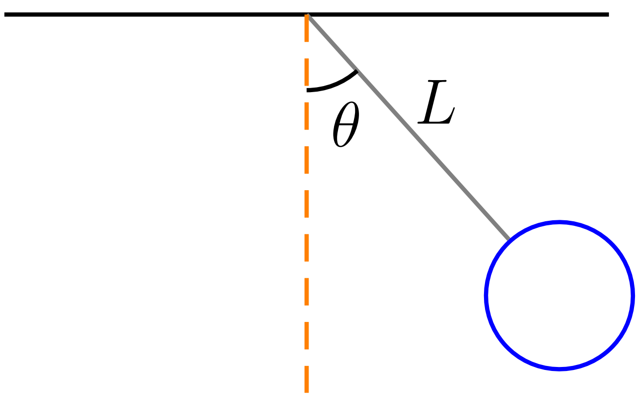

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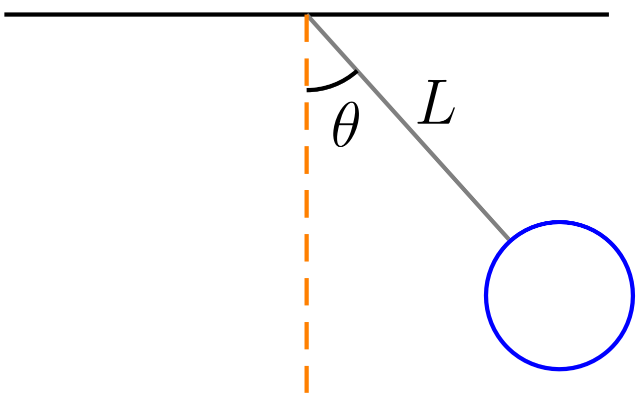

$$\sum \tau = I\alpha$$

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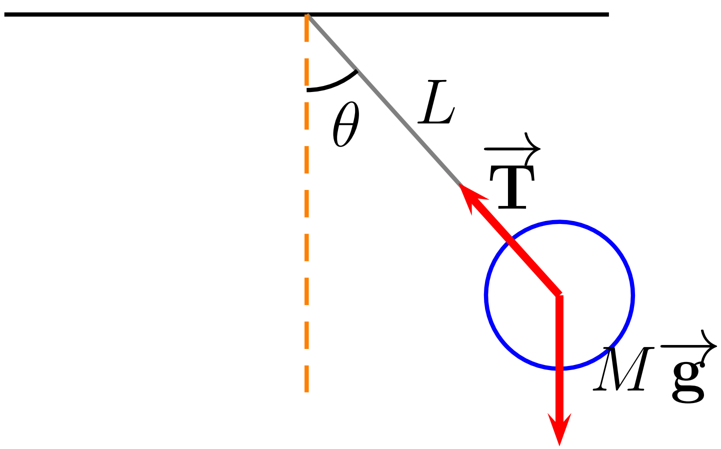

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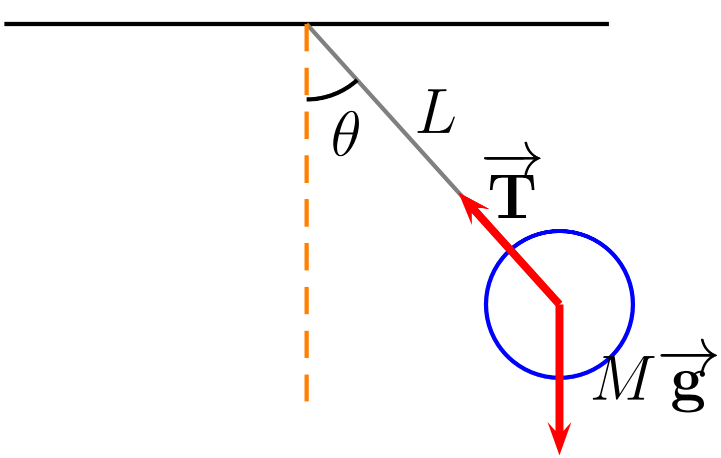

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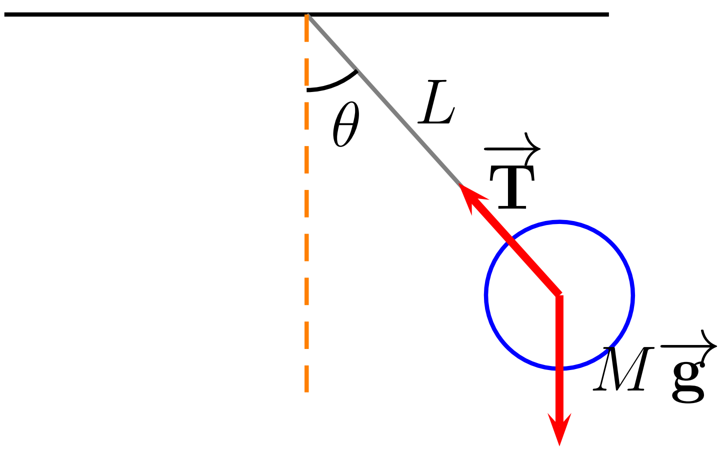

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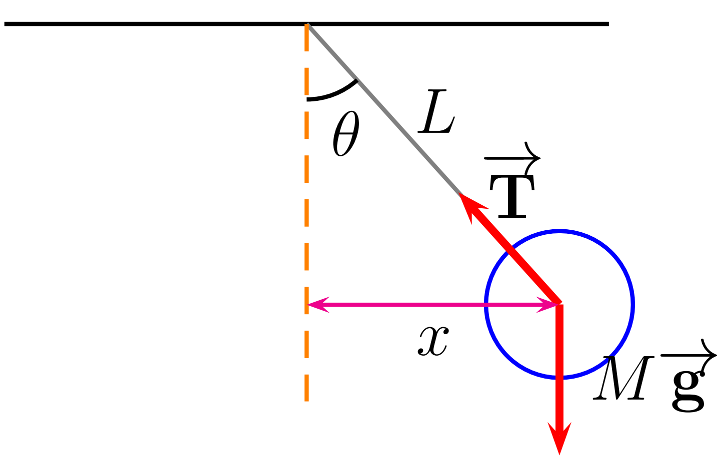

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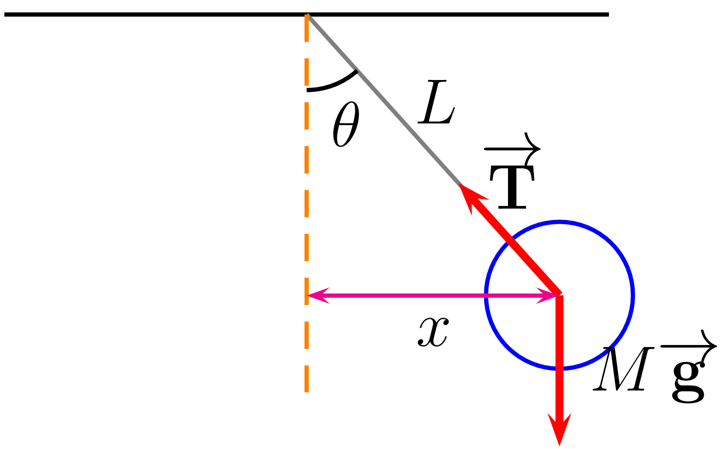

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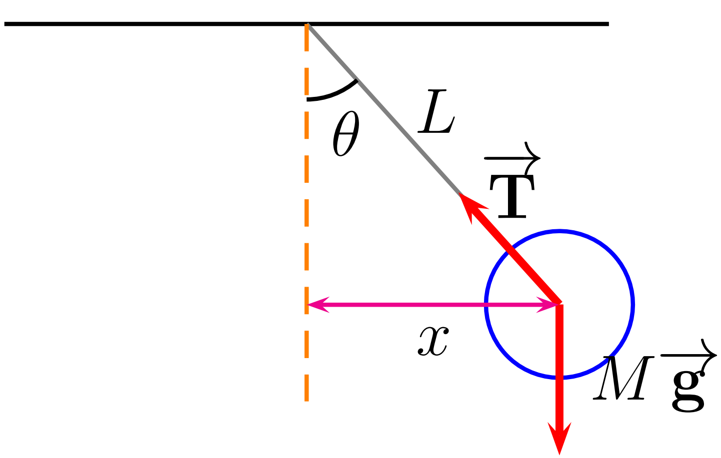


$$\sum \tau = I\alpha$$

Tension causes no torque

$$\Rightarrow \sum \tau = \tau_g = -xMg$$

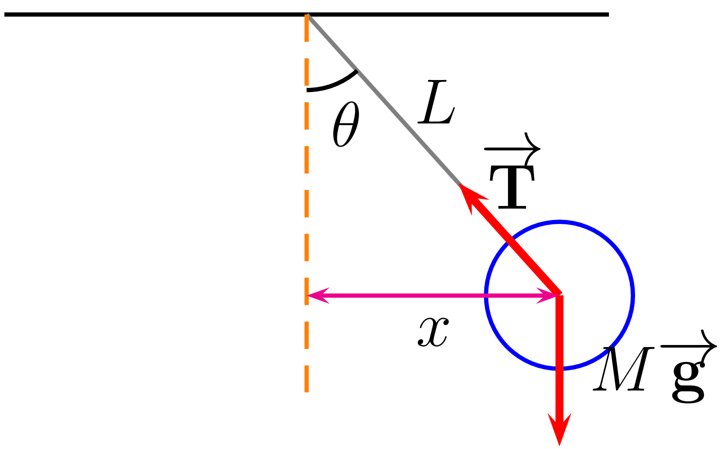
$$x = L\sin\theta \qquad I = ML^2$$

Pendulum II

Under the right conditions, a pendulum will undergo simple harmonic motion.

First Condition: No friction.

Simple Pendulum - Massless connector



$$L\left(\sin\theta\right)Mg = -ML^2\alpha$$

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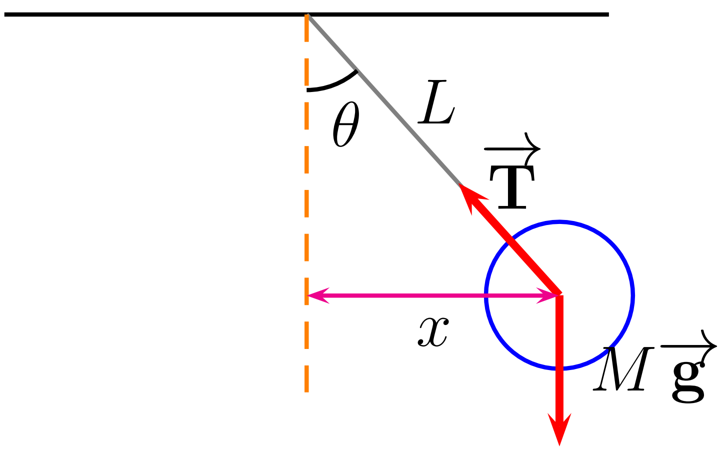

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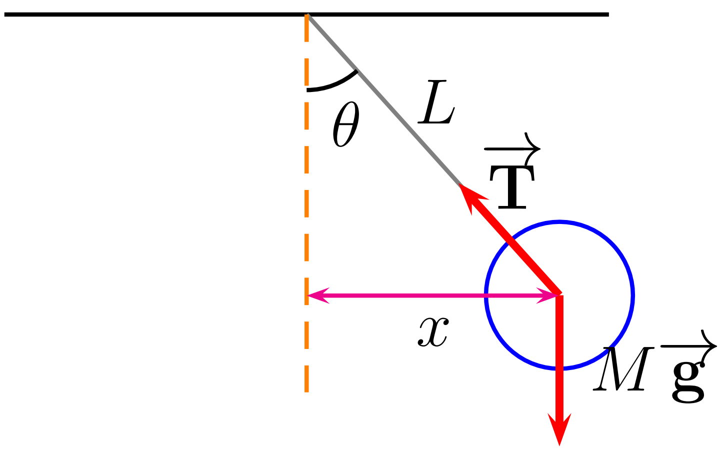

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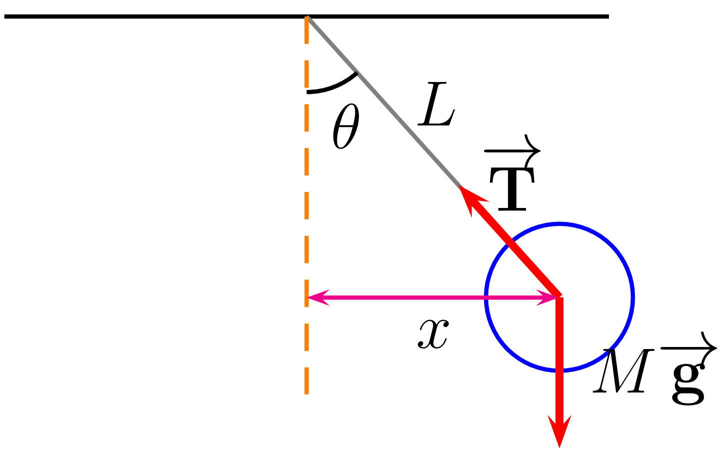

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True equation for pendulum