A block with mass \( M \) is connected through a massless cord to a block with mass \( 2m \). These are allowed to hang over a pair of masses (each \( m \)) with radius \( R \). What is the downward acceleration of the more massive block?

\[ \Sigma F_x = T_1 - mg = ma \]

\[ T_1 = ma + mg \]

\[ T_2 - T_1 = \frac{1}{2} ma \]

\[ T_3 - T_2 = \frac{1}{2} ma \]

\[ T_3 - T_2 = 2mg - 2ma \]

\[ mg = 4na \]

\[ a = \frac{1}{4} g \]
Example:

Let \( y(x, t) = 3.0 \cos \left( \frac{4\pi}{8} x - 8\pi t \right) \)

Describe a traveling wave on a string. Plot \( y(t) \) for \( x = 0 \) and \( y(t) \) for \( t = 0 \). Find \( v, \lambda, T, f \).

\[ y(t) = 3 \cos(-8\pi t) \]
\[ y(t) = 3 \cos(8\pi t) \]

\[ y(x) = 3 \cos(4\pi t) \]

\[ y(x) = 3 \cos(4\pi t) \]

\[ v = \frac{\omega}{k} = \frac{8\pi}{4\pi} = 2 \text{ m/s} \quad \text{(travels in } +x\text{ direction)} \]

\[ \lambda = \frac{2\pi}{k} = \frac{2\pi}{4\pi} = 0.5 \text{ m} \]

\[ f = \frac{2\pi}{2\pi} = \frac{8\pi}{2\pi} = 4 \text{ Hz} \]

\[ T = \frac{2\pi}{\omega} = \frac{2\pi}{8\pi} = 0.25 \text{ s} \]
Example: What is the force of gravity on a mass $m$ at a distance $r < R_\oplus$ from the center of the Earth?

\[ F = -G \frac{m M_{\text{enc}}}{r^2} \]

$M_{\text{enc}}$ is mass enclosed in sphere of radius $r$.

\[ M_{\text{enc}} = \rho \frac{4}{3} \pi r^3 \]

\[ \rho = \frac{M_\oplus}{\frac{4}{3} \pi R_\oplus^3} \]

So \[ M_{\text{enc}} = M_\oplus \frac{r^3}{R_\oplus^3} \]

And therefore:

\[ F = -G \frac{m M_\oplus}{R_\oplus^3} \frac{1}{r} \]
Example: An oxygen (O₂) molecule has a total mass of 5.3 x 10⁻²⁶ kg.

If the moment of inertia about an axis passing through the midpoint of the line segment connecting the oxygen atoms is 1.9 x 10⁻⁴⁶ kg m², what is the separation between the O atoms?

\[ I = \frac{m}{2} (\frac{D}{2})^2 + \frac{m}{2} (\frac{D}{2})^2 = 1.9 \times 10^{-46} \text{ kg m}^2 \]

\[ D^2 = \frac{2I}{m} \]

\[ \frac{m}{4} D^2 = 1.9 \times 10^{-46} \text{ kg m}^2 \]

\[ D = \left( \frac{4I}{m} \right)^{1/2} \]

\[ D = 1.2 \times 10^{-10} \text{ m} = 1.2 \text{ Å} \]
(b) \[ T = \frac{2\pi}{\omega} \]

\[ \omega = \sqrt{\frac{k}{m}} \]

\[ \omega_0^2 = \frac{k}{m} \]

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Assume \[ \theta(t) = C \cos(\omega_0 t + \phi) \]

To show that \( T = T' = \frac{2\pi}{\omega_0} \).

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