Eidgenössische Technische Hochschule Zürich
Swiss Federal Institute of Technology Zurich

Continuum Mechanics
Series 1.

FS 2013
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Exercise 1. ***Impulse***

Consider a bar of radius r and length L oriented lengthwise along the x axis.

1.1. ***Suppose r=0***

(a) If we poke the bar at $L/2$ with an impulse $F\Delta t$ compute v

(b) If we poke the bar at L with an impulse $F\Delta t$ compute v

1.2. ***Suppose r is non zero.***

(a) If we poke the bar at $L/2$ with an impulse $F\Delta t$ compute v

(b) If we poke the bar at L with an impulse $F\Delta t$ compute v

Exercise 2. ***Virial Theorem***

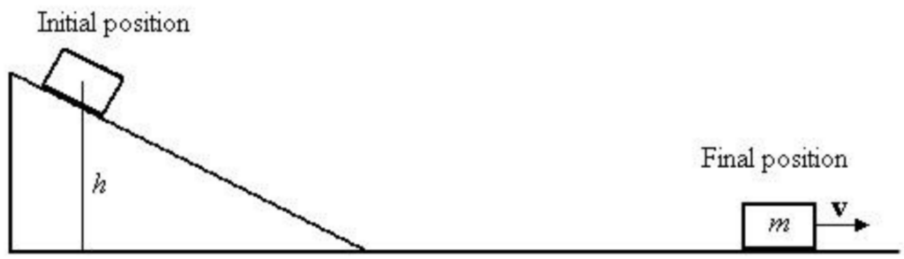
Suppose that we have a gravitationally bound system that consists of N individual objects (stars, galaxies, globular clusters, etc.) that have the same mass m and an average velocity $\bar{v}$. Additionally we can measure the dispersion of this velocity σ defined as $\sigma = \overline{v^2} - \bar{v}^2$

(a) Use the virial theorem to estimate the total mass of the system

(b) Suppose a system has a total extent of $R = 2 \times 10^{18}$ km and a velocity dispersion of 160 km/s. Derive the total mass of the system.

(c) A respected astronomer measured the visible mass of the system to be $\approx 10^{10} M_{\odot}$ or $\approx 2 \times 10^{40}$ kg. Why is there a discrepancy with your derivation?

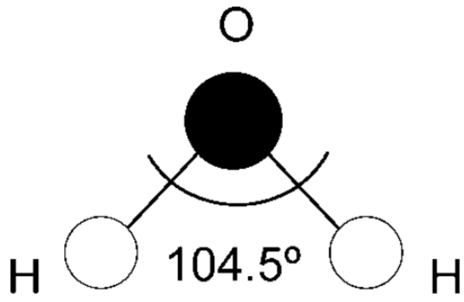
Exercise 3. ***Work-Energy Theorem***



Compute the final velocity of the block above. Assume the block slides with no friction.

Exercise 4. ***Moment of Inertia***

The water molecule, H_2O, is composed of 2 atoms of hydrogen each bonded to one atom of oxygen in a triangular arrangement. The oxygen-hydrogen bonds have a length $r = 9.6 \times 10^{11}$m and are set apart by an angle of $104.5°$. Treat each atom as a point mass.



(a) Determine the center of mass position of the water molecule

(b) Find the principal axes that pass through this center of mass

(c) Confirm these axes by calculating the moment of inertia tensor in the principal axes frame. You can write your answer in terms of bond length r and hydrogen mass m_H