Physics 1a, Section 2

October 21, 2010

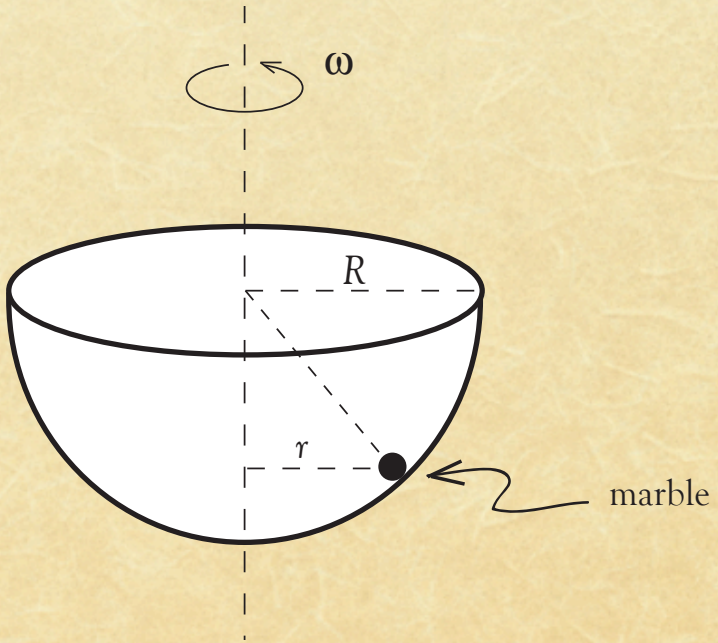
Second Quiz

- covers:
  - Frautschi chapters 4 - 8.4 (and 1 - 3)
  - lectures/sections through yesterday (Oct. 20)
  - homework #2-3 (and #1)

Quiz Problem 37

Problem 2 (6 points) - Marble in a Bowl

A marble of mass m is deposited inside a hemispherical bowl of radius R, as shown in the figure. The bowl is then spun around its vertical axis with a constant angular velocity ω. The marble eventually settles at a distance r from the bowl's vertical axis while rotating around that axis with the same angular velocity ω as the bowl itself.



(a) (3 points) Find the force that the bowl exerts on the marble. Give the total magnitude of the force as well as its angle with respect to the vertical axis of the bowl.

(b) (2 points) Derive an expression for r in terms of R, ω, and the gravitational acceleration g.

Note that, for small enough ω, the answer to part **(b)** does not make sense.

(c) (1 point) Explain what happens physically when the angular velocity ω is too small.

Quiz Problem 37

- Answer:

a) $N = m\omega^2 R$, $\cos\theta = g/(\omega^2 R)$

b) $r = (R^2 - g^2/\omega^4)^{1/2}$

c) When $\omega <= (g/R)^{1/2}$, marble sits on bottom of bowl

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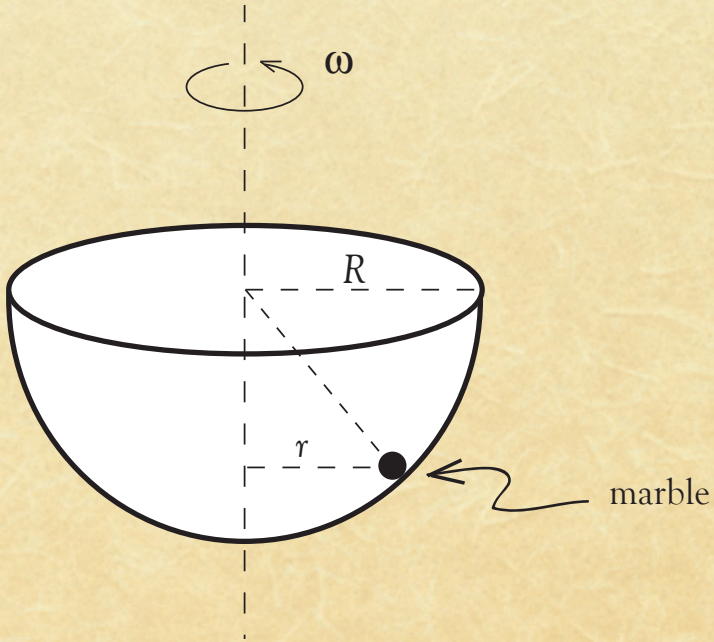

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Problem Solving Hints: Normal Force and Friction

- suggested order:

  1) draw gravity and other fixed external forces (direction and magnitude are unambiguous)

  2) draw normal force (prevents interpenetration of objects)

  3) draw friction force (perpendicular to normal force)

- **kinetic friction:**

  $F = \mu_k N$

  direction opposite to relative velocity

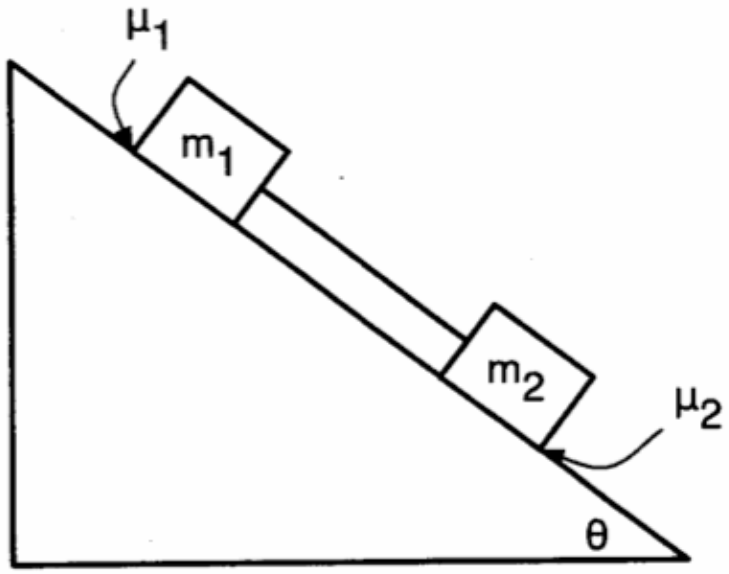
- **static friction:**

  $F \leq \mu_s N$

  direction and magnitude to prevent relative acceleration

Quiz Problem 48: kinetic friction

Two masses connected by a string slide down a ramp making an angle θ with the horizontal, as shown in the figure below. The mass m_1 has a coefficient of kinetic friction μ_1 and the mass m_2 has a coefficient of kinetic friction μ_2. Assume the string is massless and remains taut as the masses slide down the incline.



(a) **(4 points)** Draw the free body diagrams for both masses, showing the forces acting on each as they slide down the ramp. Write down the equations of Newton's Second Law for both m_1 and m_2.

(b) **(4 points)** Find the acceleration a of the masses and the tension T of the string. Give your answers in terms of m_1, m_2, μ_1, μ_2, g and θ.

(c) **(2 points)** Find the condition on μ_1 and μ_2 such that the string indeed remains taut as the masses slide down the incline.

Quiz Problem 48

- Answer:

a) $m_1a = T + m_1g(\sin\theta - \mu_1\cos\theta)$,
$m_2a = -T + m_2g(\sin\theta - \mu_2\cos\theta)$

b) $a = g[\sin\theta - \cos\theta(m_1\mu_1+m_2\mu_2)/(m_1+m_2)]$,
$T = g\cos\theta(\mu_1-\mu_2)m_1m_2/(m_1+m_2)$

χ) $\mu_1 > \mu_2$

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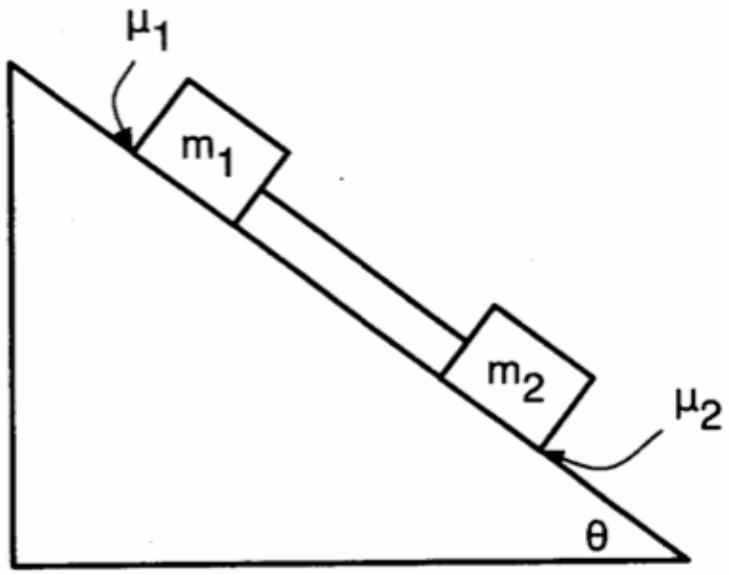

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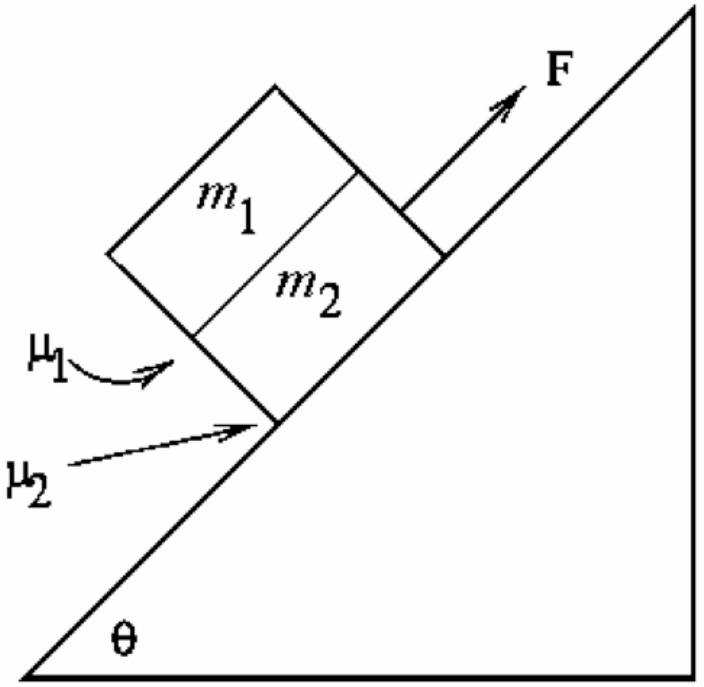
Quiz Problem 11: static & kinetic friction

Upon an inclined plane of angle is placed a block of mass m_2. Upon m_2 is placed another block of mass m_1.
The coefficient of static friction between m_2 and the inclined plane is μ_{2s} and the coefficient of sliding friction is μ_{2k}.
Likewise, the coefficient of static friction between m_1 and m_2 is μ_{1s} and the coefficient of sliding friction is μ_{1k}.
A force F upward and parallel to the plane is applied to $m2$.



(**2 points**) (a) What is the acceleration of m_2 when m_1 just starts to slip on it?

(**2 points**) (b) What is the maximum value of F before this slipping takes place?

Quiz Problem 11

- Answer:

a) $a = g(\mu_{1s}\cos\theta - \sin\theta)$

b) $F = (m_1+m_2)g(\mu_{2k} + \mu_{1s})\cos\theta$

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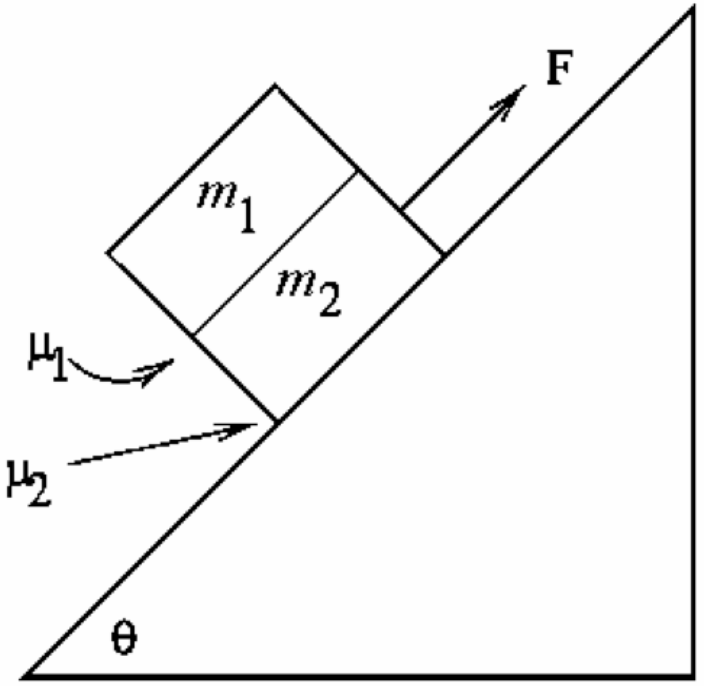

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Monday, October 25:

- Quiz Problem 29 (non-inertial frames)
- Quiz Problem 49 (springs)

- *Optional, but helpful, to try these in advance.*