

~~It is strongly recommended that you read about a subject before it is covered in lectures.~~

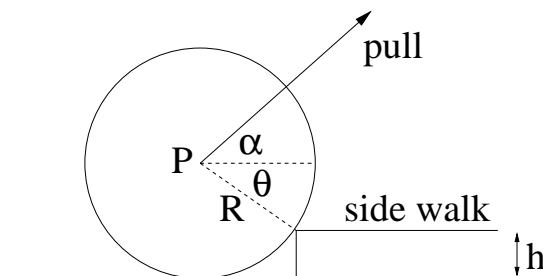
Lecture Date	Material Covered	Reading
#33 Fri 12/3	Kinetic Gas Theory - Ideal Gas Law PIVoT Isothermal Atmosphere Phase Diagrams - Phase Transitions	Page 494 - 504 Take Notes!
#34 Mon 12/6	The Wonderful Quantum World Breakdown of Classical Mechanics	Take Notes!
#35 Wed 12/8		Bring a Friend

~~There is no due date for this assignment, and it will not be graded.~~

~~Solutions will be posted on Dec 10.~~

10.1 *Lifting a Drum up the Sidewalk*

A cylinder of mass M and radius R is lying on the street against the sidewalk. The height of the sidewalk is h . A rope is attached to the axis at each end (point P and Q) of the cylinder (we only show point P in the figure). We pull on the ropes (with equal force) perpendicular to the axis at an angle α with a horizontal plane so as to just lift the cylinder off the street.



- What is the ratio of this force (2 ropes combined) to the weight of the cylinder? Express your answer in terms of α , θ , M , and g .
- At what angle of α is the ratio as described under a) a minimum, and at what angle is it a maximum? Use $\theta = 30^\circ$.

10.2 *Strain, Stress and Oscillations*

~~A mass of 400 kg is hanging from a nylon rope of length 5 m and diameter 1 cm. We pull the mass down from its equilibrium position over a distance of 3 cm. (The stress is proportional to the strain.) Since the mass of the rope is much less than 400 kg you may neglect it.~~

- ~~Calculate the force needed to do this.~~
- ~~The mass is now released and it starts to oscillate vertically. Is the motion a SHO? What is the period of one oscillation?~~
- ~~We now pull the mass down 10 cm from equilibrium and we release it. The stress is still proportional to the strain. Is the motion now a SHO?~~
- ~~How much mass can we hang on the rope before it breaks? Any idea how long the rope then is?~~

10.3 *Archimede's Principle*

~~A uniform block of wood floats in water with two-thirds of its volume submerged. In oil it has 90% of its volume submerged. What is the density of the wood and of the oil?~~

Solutions for Assignment # 10

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Problem 10.1

(a) We pull with a force F (both ropes combined). At the point O the sidewalk exerts an unknown force F' on the cylinder. The condition for just lifting the cylinder off the street is $N = 0$ where N is the usual normal force the street exerts on the cylinder. We can eliminate F' by measuring all torques about O . (A torque is defined as positive if it would cause the cylinder to roll up the sidewalk.) The condition for just rotating about the corner is $\tau = 0$ where τ is the total torque about O .

$$0 = FR \sin(\pi - (\theta + \alpha)) - MgR \sin\left(\pi - \left(\frac{\pi}{2} - \theta\right)\right) = FR \sin(\theta + \alpha) - MgR \cos \theta$$

where we use the trigonometric identities $\sin(\pi - x) = \sin x$ and $\sin\left(\frac{\pi}{2} + x\right) = \cos x$. Solving the above equation for F gives

$$\frac{F}{Mg} = \frac{\cos \theta}{\sin(\theta + \alpha)}$$

(b) A local minimum or maximum occurs when

$$0 = \frac{dF}{d\alpha} = -Mg \cdot \frac{\cos \theta \cos(\theta + \alpha)}{\sin^2(\theta + \alpha)}$$

The only solution to the above equation is

$$\cos(\theta + \alpha) = 0 \quad \implies \quad \alpha = 90^\circ - \theta$$

For $\theta = 30^\circ$ then $\alpha = 60^\circ$. By plotting $\frac{F}{Mg}$ we see that $\alpha = 60^\circ$ is a local minimum and the global minimum and $\alpha = 0$ is the global maximum (not local). It's not hard to show that if $\theta < 45^\circ$ then the maximum is at $\alpha = 0^\circ$, and if $\theta > 45^\circ$ then the maximum is at $\alpha = 45^\circ$.