Physics 303K Handout 5

1. **Midterm #1 retrospective**
   Next time, be careful which folder you put your bubble sheet in. There were two folders for 56485 (Regular) bubble sheets and cheat sheets and there were two other folders for 56585 (Honors) bubble sheets and cheat sheets. Average grade: $166.5/240 \pm 41.6$.

2. **Friction**

   (a) **Direction of frictional forces** Friction is generally the interaction of one body with another via contact. The frictional force on object A acts in the opposite direction of the *tangential* force applied by object A to object B. The friction being tangential means friction acts only in the direction of the contact.

   (b) **Intermolecular interactions and friction** The details of friction depend on the microscopic scale of the 'stick and slip' contacts. We replace these complicated details with an empirical constant coefficient. We approximate that friction is independent of the surface area of the contact and proportional to the normal force. It is a tradeoff: We do lose the source of friction in the microscopic physics, but we gain insight and a powerful, easy-to-use understanding.

   (c) **Magnitude of frictional forces** The *maximum* static frictional force that a dry (unlubricated) contact can supply is $\mu_s N$, where μ_s is the coefficient of static friction and N is the normal force. The frictional force that a dry sliding contact supplies is $\mu_k N$, where μ_k is the coefficient of kinetic friction. Note the kinetic friction is approximated as independent of the relative speed of the contact surfaces. Usually, $\mu_s > \mu_k$. This makes sense if you think about a car on ice.

   (d) **Normal Force** The normal force arises because of the atoms of the material acting as a spring with very high spring constant. The normal force is always perpendicular to the surface. The normal force is *not* the reaction force of the object on the surface (because action-reaction pairs are always on different objects)!

   (e) **Rolling vs Sliding** When dealing with a rolling tire, use the coefficient of static friction. When dealing with a sliding tire, use the coefficient of kinetic friction. The work to roll a wheel is much less than it is to slide a wheel. This is because it is easier to peel off the microscopic contacts than it is to shear them off. Think of Scotch tape: it is easy to peel off, but hard to shear off.

   (f) **Methods to reduce friction** Lubrication by a liquid, lubrication and support by a layer of gas, support by a magnetic force.

3. **Ideal Strings**

   (a) Ideal strings do not stretch. They have the same length regardless of their tension.

   (b) Ideal strings are infinitely thin. Forces are transmitted only along the direction of the string.

   (c) Ideal strings are perfectly flexible. You can only pull an object with a string; you cannot push something with a string.

   (d) Ideal strings have no mass. The force you pull with is the force that is applied to the object in tow.

   (e) A Note on Spring scales: If an ideal string was cut and a spring scale was inserted, the tension would read T, not $2T$.

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