Notes

Reminders:

• Help Sessions:
  – M, 6:30-8:30pm, T, 8:00-10:00pm, DBRT B-011

• Office Hours: Mon 3-5pm, Tues, 2-4pm, NSH 414

• Exam Thursday! Review Wednesday, 7-9pm, HH127
  – Will cover up to and including chapter 5
    • (not section 5.8, Friction)
  – 7:45am, Hesburgh Library Auditorium
    • By «Au Bon Pain»

– Problem set will be due Wednesday, as usual
– Make sure to check out practice exams!
Limits:  
\[ T = g \left( 1 + \sin \theta \right) \left( \frac{m_1 m_2}{m_1 + m_2} \right), \quad a = g - \frac{T}{m_2} \]

\[ = g - g \left( 1 + \sin \theta \right) \left( \frac{m_1}{m_1 + m_2} \right) \]

\[ \Theta \to 90^\circ, \quad \sin \theta \to 1, \quad T \to 2g \left( \frac{m_1 m_2}{m_1 + m_2} \right) \leftarrow \text{Atwood's Machine!} \]

\[ m_1 \text{ or } m_2 \to 0, \quad T \to 0 \]

\[ m_1 \to 0, \quad a \to g \quad \leftarrow m_2 \text{ falls} \]

\[ m_2 \to 0, \quad a \to -g \sin \theta \quad \leftarrow m_1 \text{ slides down plane} \]

Please go back and compare these with Friday's notes.
Trout in an elevator: \[ \sum F = ma = F_{sc} - mg \]

A trout hangs from a scale in an elevator, as shown. The trout has mass 2 kg. What does the scale read if:

a) the elevator is at rest \[ a = 0, \quad 0 = F_{sc} - mg, \quad F_{sc} = mg \]
b) the elevator accelerates upward at 2 m/s²

c) the elevator moves upward at 4 m/s

d) the elevator accelerates downward at 4 m/s²

e) the elevator cable breaks

b.) \[ ma = F_{sc} - mg, \quad F_{sc} = ma + mg = 23.6 \text{ N} \]
c.) \[ a = 0, \quad F_{sc} = mg = 19.6 \text{ N} \]
d.) \[ ma = F_{sc} - mg, \quad F_{sc} = ma + mg = 11.6 \text{ N} < mg \]
e.) \[ ma = F_{sc} - mg, \quad a = -g \Rightarrow -mg = F_{sc} - mg \]
\[ F_{sc} = 0 \rightarrow "weightless" \]
Newton's Third Law:

LEX III.

Actioni contrariam semper et æqualem esse reactionem: sive corporum duorum actiones in se mutuo semper esse æquales et in partes contrarias dirigi.

Old Translation:
To every action there is always opposed an equal reaction: or, the mutual actions of two bodies upon each other are always equal, and directed to contrary parts.

What we really mean:
Forces always occur in equal and opposite pairs. If object $A$ exerts a force on object $B$, an equal but opposite force is exerted by object $B$ on object $A$. 
\( F_g = \frac{G M_E m}{r_E^2} = g m = ma \)

\( F_g = \frac{G m M_E}{r_E^2} = a_E M_E = ma \)

\( a_E = \frac{m}{M_E} a \)

\( a_E = \frac{m}{M_E} g \)

\( |N| = |N| \)

\( |mg| = |mg| \)

\( N 3^{rd} \) Pairs

diff. objects

on prof.

on earth

opp. dir.
A locomotive pulls a series of wagons. Which is the correct analysis of the situation?

1. a) The train moves forward because the locomotive pulls forward slightly harder on the wagons than the wagons pull backward on the locomotive.

2. b) Because action always equals reaction, the locomotive cannot pull the wagon the wagons pull backward just as hard as the locomotive pulls forward, so there is no motion.

3. c) The locomotive gets the wagons to move by giving them a tug during which the force on the wagons is momentarily greater than the force exerted by the wagons on the locomotive.

4. d) The locomotive’s force on the wagons is as strong as the force of the wagons on the locomotive, but the frictional force on the locomotive is forward and large while the backward frictional force on the wagons is small.

5. e) The locomotive can pull the wagons forward only if it weighs more than the wagons.
Two 5kg masses are connected to a scale, and the masses are at rest. The scale reads in kg. What is the reading on the scale?

\[ T = 5 \text{ kg} = \text{scale reading} \]
Friction

$F \propto N$

$\Rightarrow$ always resists tendency to move

**Static Friction**

$F_s \leq \mu_s N$

$\Rightarrow$ coeff. of static friction

$\Rightarrow$ object moves when $F$ exceeds $F_s$

$\Rightarrow F_{s\text{ max}} = \mu_s N$

**Kinetic Friction**

$F_k = \mu_k N$

$\downarrow$ coeff. of kinetic friction

usually, $\mu_k \leq \mu_s$
Friction and Inclined Planes

Can we relate $M_s$ and $\theta$?

$$\sum F_y = N - mg \cos \theta \Rightarrow N = mg \cos \theta$$

$$= mg \sin \theta = 0$$

$$F_{\text{max}} = M_s \cdot N = M_s \cdot mg \cos \theta$$

$$\sum F_x = \text{max} = 0 = mgsin\theta - F_s$$

$$mgsin\theta - M_s \cdot mg \cos \theta = 0$$

$$M_s = \frac{\sin \theta}{\cos \theta} = \tan \theta$$