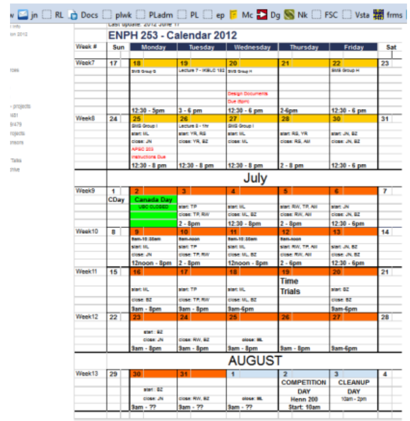
ENPH 253 – Lecture 7

- Design Document - Wed June 20th
  - 6pm in person, or by 12midnight via email.
- The First Few Weeks of Build-Time
- Project Management & Teamwork
- Motors
- Circuit Planning



The First Few Weeks of Fabrication Time

Rapid Testing with Thorough Planning

- Quickly build any necessary prototypes to verify your idea
  - Do your motors have sufficient torque?
  - Will your structure be stiff enough?
  - Will you have too much friction? (or enough friction?)
  - Can you verify your mech calculations are correct?
- Get COMPLETE designs on paper, then show TA's/instuctors
  - It's far easier to pick out design flaws if you have a "complete" design.
- Look at previous robots for design examples and things to avoid.

4

Stories from last year's competition –

5

General Fabrication Rules

- External parts:
  - Verify ALL your parts with us before ANY purchases
    - we sometimes say no, and we sometimes buy the parts for the entire class
  - We don't reimburse any team-spent money
- Mech Fabrication:
  - Sign-up for use of waterjet cutter, SMS in Hebb 42
  - Record waterjet cutting at the machine (we get charged $1/min).
  - Aim to minimize wasted material.
  - We can recycle aluminum and steel, some plastics too.
- Electronics fabrication:
  - Maintain written schematics for all circuits.
  - We can't help you unless you have schematics!

Safety at all times

1. Wear covered shoes at all times (we'll send you home)
2. Wear eye protection when appropriate (e.g. cutting wires, while soldering)
3. Keep your areas clean.

Project Management & Teamwork

Project Management

1. **Write down your plan.** Always write down your plan!
2. **Track your time usage.** Useful to identify the most time-intensive and inefficient areas.
3. **Update your status.** A point-form plan / group meeting every 2-3 days (maybe daily?) helps keep organized and refocus your efforts.
4. **Aim for continuous improvements**, rather than big gains after a big time investment.
5. **Better is the enemy of good** (Know when to stop tweaking!)
6. There is never enough time to do everything. But there is ***always enough time to do the most important things.***
7. If you aren't busy, **help your teammates**.
   7.a. If you are busy, structure your work to let your teammates help!
8. Problems? Let the instructors/ TA's know ASAP.

9

Teamwork

"Good" team members have a number of traits:

1. **Keep informed of the team's efforts:** The best teams don't necessarily have everyone do everything, but everyone knows the overall plan, timeline, and current problems.
2. **Keep other team members motivated and productive:** It is an invaluable skill to learn how to get the most out of your teammates.
   1. Help clarify tasks and goals for team members
   2. Seek clarity on level of commitment for the effort
3. **Seek to address internal team issues early on** There is an end-of-term peer review, But don't wait until end-of-term to address team issues! Contact course instructors if you find you have issues with:
   1. Communication
   2. Project planning and time allocation
   3. Motivation
   4. Decision-making

10

Motors

DC electric motors: estimating performance

- Sometimes you are given a graph for motor specifications, but usually you are only given a few operating parameters

Example motor:

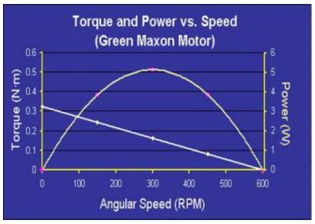
BaneBots, 11:1, 16mm Spur Gearmotor, FF-050

Operating v	: 4.5v - 8v	
Nominal v	: 6v	
No Load RPM	: 1366	
No Load A	: 0.2A	
Stall Current	: 1.9A	
Stall Torque	: 10 oz-in (72 mN-m)	
Kt	: 5.4 oz-in/A	(38 mN-m/A)
Kv	: 228 rpm/v	

12

DC electric motors: torque curves

- There is a linear relationship torque & speed for most small DC motors (for geared or ungeared motors).
- You can estimate a torque-speed curve using only 2 parameters: stall torque (maximum torque) and no-load speed (max speed):

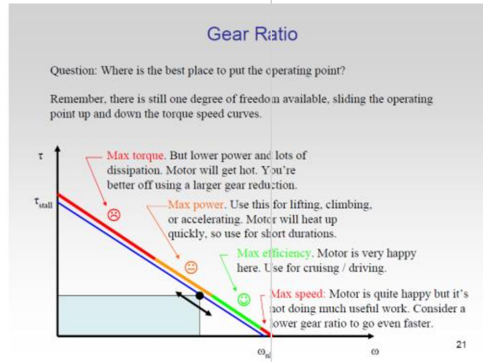


For Motor Power:

P = T * ω
= (torque) * (ang velocity)
= 0 when T=0 or
= 0 when ω = 0

P ~ maximum when at mid-point (½ T_{max} * ½ ω_{max})

Image from: http://lancet.mit.edu/motors/index.html



Info from MIT 2.007 course – a great resource!

http://stellar.mit.edu/S/course/2/sp10/2.007/courseMaterial/topics/topic5/resource/DCmotors/DCmotors.pdf

Estimating whether or not your motor is appropriate for the job

1. Estimate desired power for the final application of the motor (How fast does it need to go? How much force is desired to get it to operate? How much max torque do you need at what speed?)

   → $P_{requried}$ = Fv
   = Tω

2. Check that motor can provide adequate power (from torque and speed specs)

3. Design a drive train to go from the motor torque/speed to get the desired torque/speed.

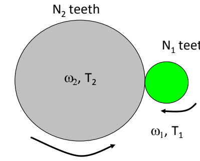
Gear Train / Drive Train Ratios

power in = power out

$T_1 \omega_1 = T_2 \omega_2$

Torque and speed both scale WRT the number of teeth on the input and output shafts.

Slower = more torque.
Faster = less torque

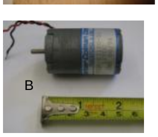


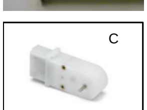
Angular velocity: $N_1 \omega_1 = N_2 \omega_2$

Torque: $(T_1 / N_1) = (T_2 / N_2)$

Drops in efficiency at each drive train stage are hard to estimate, and will depend on how well things are assembled, frictional losses, etc.

Motors supplied in 253 lab



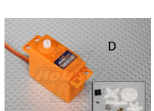


A. Geared Barber Coleman motor (FYQF 63310-9) (at 12V)
no-load speed: 470 rpm max torque: 28 oz-in (20 N-cm)
no-load current: 0.1A stall current: 1.3 A

B. Un-geared Barber Coleman motor (FYQM 63100-51) (at 12V):
no-load speed: 2300 rpm max torque: 5.2 oz-in (3.7 N-cm)
no-load current: 0.13A stall current: 2.75 A

C. GM7 (BabyGM3) (at 6V)
no-load speed: 146 rpm max torque 23.78 oz-in (17 N-cm)
no-load current 92mA stall current 524mA

D. Large Servo Motor (motor + built-in encoder) (at 5V)
max torque: 59 oz-in torque (42 N cm)
max speed: 0.21 / 60deg @4.8v

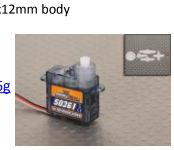


3 sizes of Servo Motors

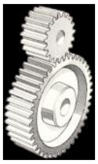
HK15138 Standard Analog Servo 38g
Torque ~ 42 N cm
40x20 mm body
(same body as existing black futaba-style motors, slightly more torque)

HK15178 Analog Servo 10g
Torque ~13.7 N cm
23x12mm body

Hobby King S0361 3.6g
Torque ~ 4.4 N cm
19.8 x 8.1 mm body



Gears



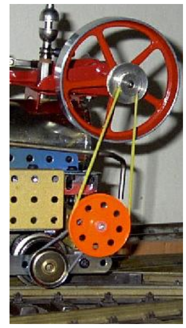
Spur Gears

Rack and pinion

Right-angle gearing with
bevel gears (above)
or crown gears (below)

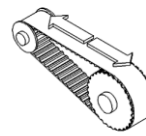
Worm gear - lots of torque but slow
N:1 ratio (N = # teeth on spur gear)

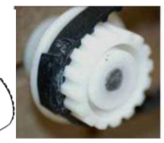
Pulley drives



- Use same ratio calculations as with gears, except use diameters instead of teeth
- May slip, which may or may not be a good thing (bad for accuracy, good for protection)

Timing belts have beads or rubber teeth to minimize the chance of slipping

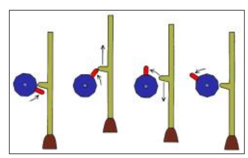


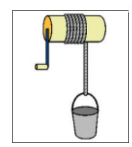


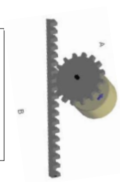
Linear Motion

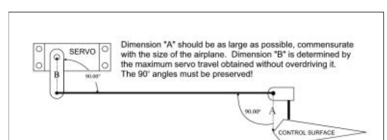
- **Can be tricky** if you don't account for gravity and binding.
- **Look at commercial linear stages** for design attributes to help avoid binding.
- **Review Robin Coope's notes** (pg. 77-81 in "how to make things")
- **Rotation is easier**; use Rotation instead of linear motion wherever you can.

Linear motion from rotary motion - other eg's









http://eastbay-rc.blogspot.ca/2010/10/setting-up-your-airplane.html