2.007 Design and Manufacturing I
Spring 2009

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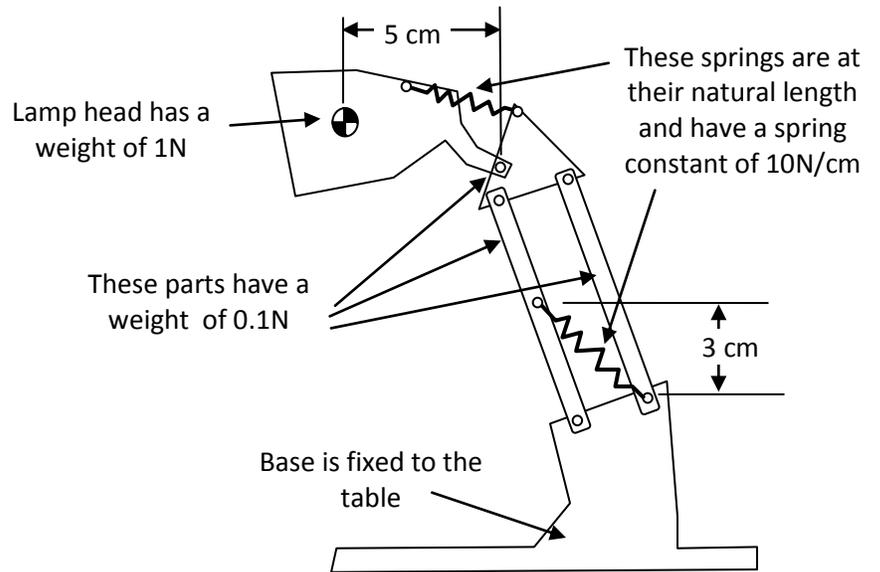**Draft Exam on Gears, Springs, Mechanisms, and Drawing**

This is a practice exam. On the real exam, you'll have 1.5 hours to answer about 7 questions. This exam is somewhat longer and would take about 2.5 hours by my reckoning. Point allocations (out of 100 total) are listed for each question based on what they'd be worth on the real exam. So, this practice exam adds up to about 160 points.

1. (10 points) Define the term "hysteresis." Explain its significance for sensors and for energy storage elements (e.g. rubber bands).

2. (10 points) You fill a one liter container with air at 60 psi gauge pressure and plan to use it as a source of power for a machine. The air in the bottle is at thermal equilibrium with the air in the room at 20 degree Centigrade. Estimate the force applied if a valve is opened connecting the reservoir of air to a piston with a three inch internal diameter and a four inch throw.

3. (20 points) Sketch the mechanism in a position that places it in static equilibrium. Assume the joints have negligable friction. The drawing is scaled properly in all dimensions so you can estimate any dimensions you need from the figure.

Briefly justify your solution with a couple equations, schematic diagrams, and/or a few sentences of explanation.

5 cm

These springs are at their natural length and have a spring constant of 10N/cm

Lamp head has a weight of 1N

These parts have a weight of 0.1N

3 cm

Base is fixed to the table

4. (20 points) The subproblems below refer to the page from a bearing catalog provided here.

A) (5 points) If gear PX32B-10 and PX32B-20 are mated together in a gear train, how far apart should the centers of their shafts be placed?

B) (5 points) If gear PX32B-10 and PX32B-20 are mated together in a gear train and a torque of 2 ft lbs is applied to PX32B-10, what is the torque on PX32B-20?

Spur Gears

24, 32, 48, and 64 Pitch   1/8" Bore   AGMA Quality 4
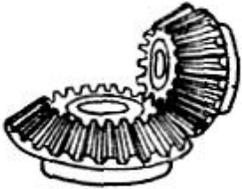**Cold Rolled Steel and Brass   20° Pressure Angle**
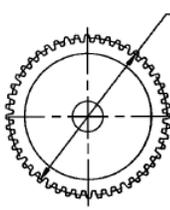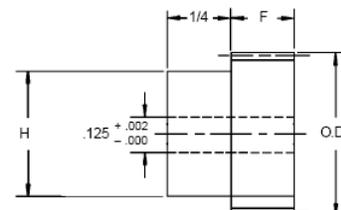
COLD ROLLED STEEL C12L14 OR C12L15 WITH SELENIUM	BRASS ALLOY 360					
STOCK NUMBER	STOCK NUMBER	NO OF. TEETH	PITCH DIA.	OUTSIDE DIA.	H	F
24 PITCH (.1309)						
PX24S-8	PX24B-8	8	.333	.416	.208	
PX24S-9	PX24B-9	9	.375	.458	.250	
PX24S-10	PX24B-10	10	.417	.500	.291	
PX24S-12	PX24B-12	12	.500	.583	.375	1/4
PX24S-16	PX24B-16	16	.666	.750	.542	
PX24S-18	PX24B-18	18	.750	.833	.625	
—	PX24B-22	22	.916	1.000	.792	
32 PITCH (.0981)						
PX32S-10	PX32B-10	10	.312	.375	.218	
PX32S-11	PX32B-11	11	.344	.406	.250	
PX32S-12	PX32B-12	12	.375	.437	.281	
PX32S-14	PX32B-14	14	.438	.500	.343	
PX32S-15	PX32B-15	15	.469	.531	.375	1/4
PX32S-16	PX32B-16	16	.500	.562	.406	
PX32S-18	PX32B-18	18	.563	.625	.468	
PX32S-20	PX32B-20	20	.625	.688	.532	
	PX32B-24	24	.750	.813	.656	
48 PITCH (.0654)						
PX48S-14	PX48B-14	14	.292	.333	.229	
PX48S-15	PX48B-15	15	.312	.353	.250	
PX48S-16	PX48B-16	16	.333	.375	.271	
PX48S-18	PX48B-18	18	.375	.417	.312	1/8
PX48S-24	PX48B-24	24	.500	.542	.437	
PX48S-32	PX48B-32	32	.666	.708	.604	
	PX48B-36	36	.750	.792	.687	
	PX48B-40	40	.833	.875	.770	
64 PITCH (.0490)						
PX64S-15	PX64B-15	15	.234	.265	.187	
PX64S-16	PX64B-16	16	.250	.281	.203	
PX64S-18	PX64B-18	18	.281	.312	.234	1/8
—	PX64B-24	24	.375	.406	.328	
—	PX64B-40	40	.625	.656	.578	
—	PX64B-48	48	.750	.781	.703	

P.D. (Ref.)
H   .125 +.002 −.000
1/4   F
O.D.

B 9

Berg Manufacturing "The Mark of Quality"   **1-800-232-BERG**

Courtesy of W. M. Berg, Inc. Used with permission.

C) (10 points) If gear PX32B-10 and PX32B-20 are mated together in a gear train and a torque of 2 ft lbs is applied to PX32B-10, what is the direction and magnitude of the reaction force at the shaft where PX32B-20 is mounted?   State any assumptions needed to arrive at your answer.

6. (10 points) Match the items below to the terms that describe them.

| Planetary gear set |
|---|

Extension spring

Bevel gear

Torsion spring

Compound gear train

Rack

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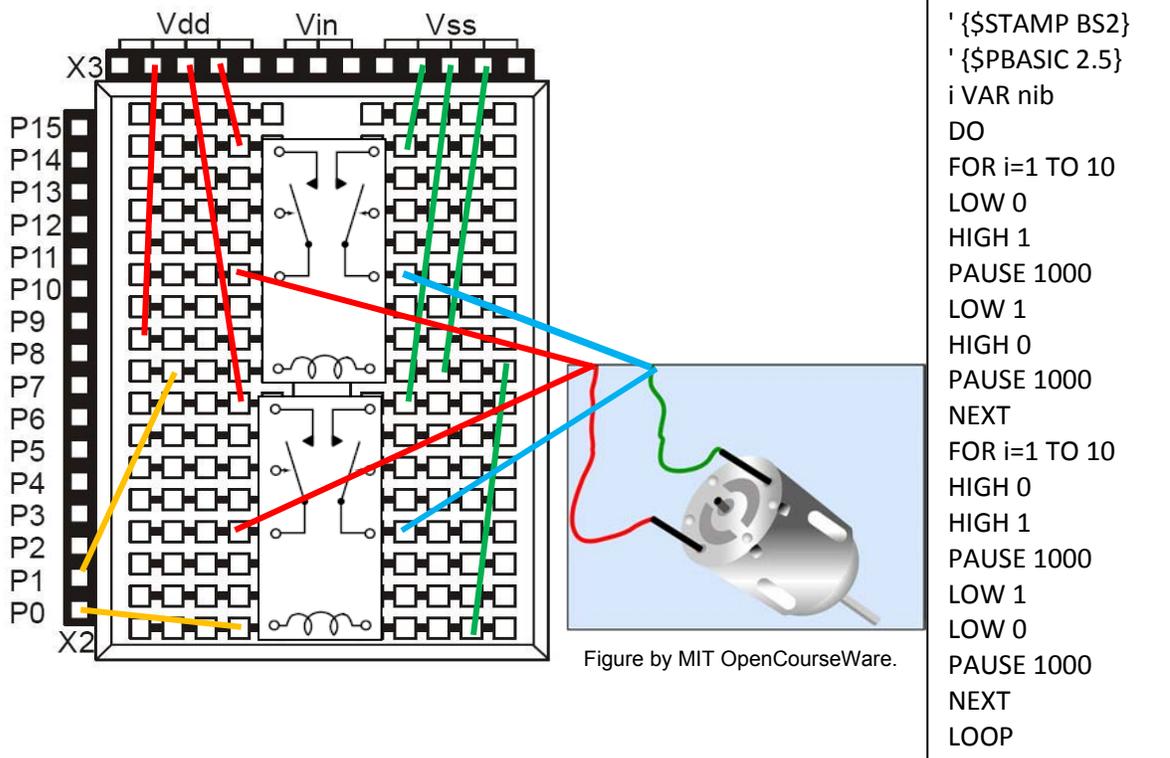
7. (10 points) It is proposed to use the arrangement below to transmit torque from the drive shaft of an engine to the rear wheels of a small vehicle. Explain why this might be a good design for a small race car yet not a good choice for a typical family sedan.
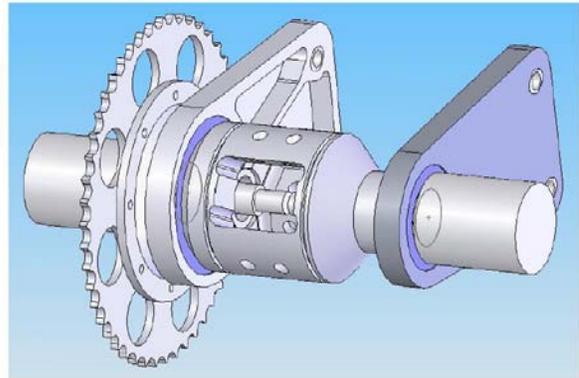
8. (10 points) A circuit is arranged with a relays, a DC motor, and sources of voltage (+5V) Vdd shown below. A set of code is downloaded to a Basic Stamp Homework board is also given below. Describe what will happen when the code is run. (The specification sheet for the relays is shown on the next page for reference.)

Figure by MIT OpenCourseWare.

```
' {$STAMP BS2}
' {$PBASIC 2.5}
i VAR nib
DO
FOR i=1 TO 10
LOW 0
HIGH 1
PAUSE 1000
LOW 1
HIGH 0
PAUSE 1000
NEXT
FOR i=1 TO 10
HIGH 0
HIGH 1
PAUSE 1000
LOW 1
LOW 0
PAUSE 1000
NEXT
LOOP
```

Text removed due to copyright restrictions.
Please see the data sheet for AZ822 subminiature DIP relays,
http://www.azettler.com/pdfs/az822.pdf

9. (25 points) Give short answers to the subquestions below.

A) (5 points) What does it mean to say that a pair of mating gears exhibit "conjugate action"?

B) (5 points) Consider the statement "the involute curve is the only shape for gears that provides conjugate action." Is this true or false? Justify your answer.

C) (5 points) Describe, in your own words, the meaning of the term "pitch diameter".

D) (5 points) Consider the statement "Gear teeth designed using an involute curve provide conjugate action even if the gears are mounted at a slightly greater distance greater than half the sum of the pitch diameters of the mating gears." Is this true or false?

E) (5 points) Name and briefly describe two different ways that spur gears are manufactured and the differences in performance and cost of the resulting gears.

10) (20 points)

A) (10 points) Make a three view drawing, complete with dimensions, of the part below. Show the dimensions on the view that best communicates each feature.

B) (10 points) Suggest a sequence of manufacturing steps to make the part. You can suggest and describe one or two small changes that would make the part easier to fabricate.
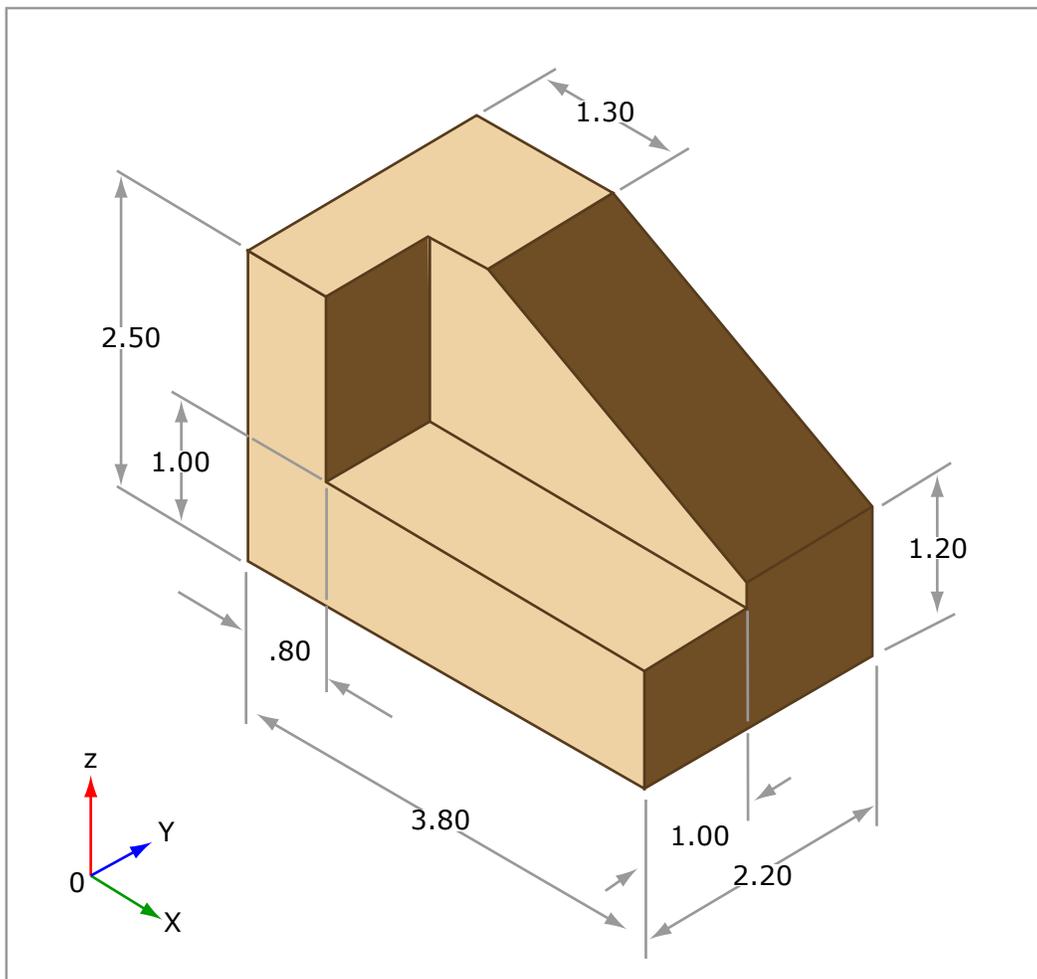

Figure by MIT OpenCourseWare.

11) (20 points) (Adapted from Shigley and Mischke, NOTE: The values of variables have been changed) A hydraulic cylinder has a diameter D = 4 inches, a wall thickness t= 1/2 inch, length L = 12 inches, and bracket thickness of w = ¾ inch. The brackets and cylinder are made of steel.

Six 3/8 in SAE grade 7 coarse threaded bolts are used and tightened to 75% of proof load (120,000psi for SAE grade 7). By how much will the bolts increase in length when the cylinder changes from applying no load to applying a load of 4000 lbs (applied at the output on the right)?
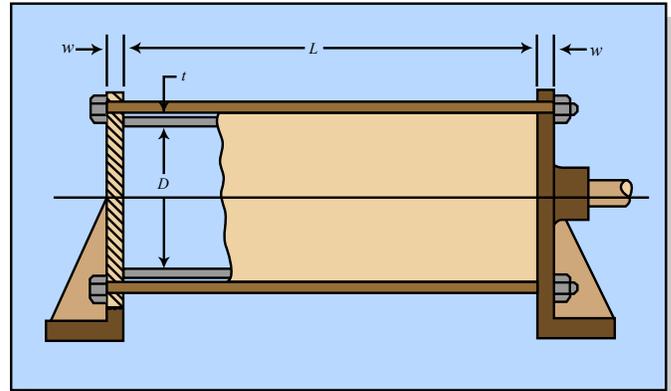
Figure by MIT OpenCourseWare.