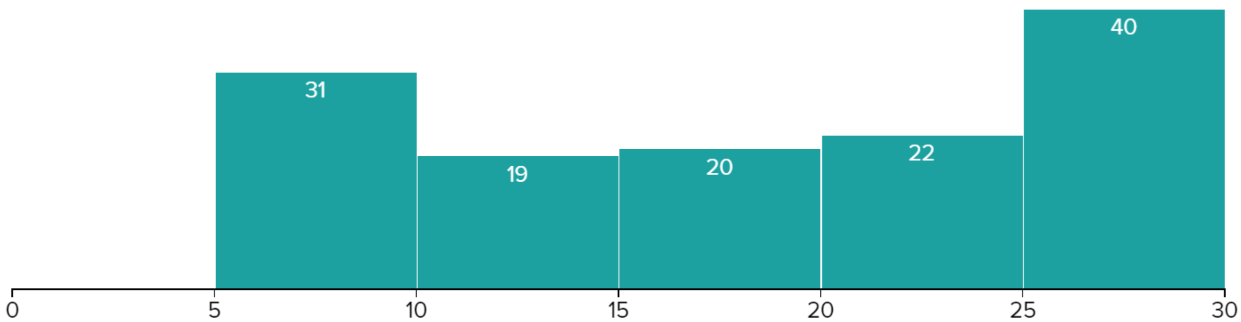
Final Exam Problem #1 (P13)

Graded by Michelle deSouza



MINIMUM	MEDIAN	MAXIMUM	MEAN	STD DEV
5.0	17.0	32.0	17.86	8.26

Comments:

- This problem was quite similar to the homework problems on this topic, e.g. #15, but was also from pretty early on in the semester.
- Most people had correct FBDs and LMBs, and put the LMBs into matrix form
- Part b) had a much lower average, likely because it required more understanding of either effective spring constants, or normal modes and eigenvalue problems. Guessing was pretty common. People who got the correct answer tended to use the effective spring constant method.

Common errors in a)

- Assuming an exponential form (i.e. positive rational roots)
- Using different frequencies in the equations -a normal mode is characterized by an identical frequency for all masses
- Assuming that the frequency was $\sqrt{\frac{k}{m}}$ without evaluating
- Finding an equation where x_2 was moving - using intuition, it should be 0 at all times
- Not using initial conditions and using a sine instead of cosine

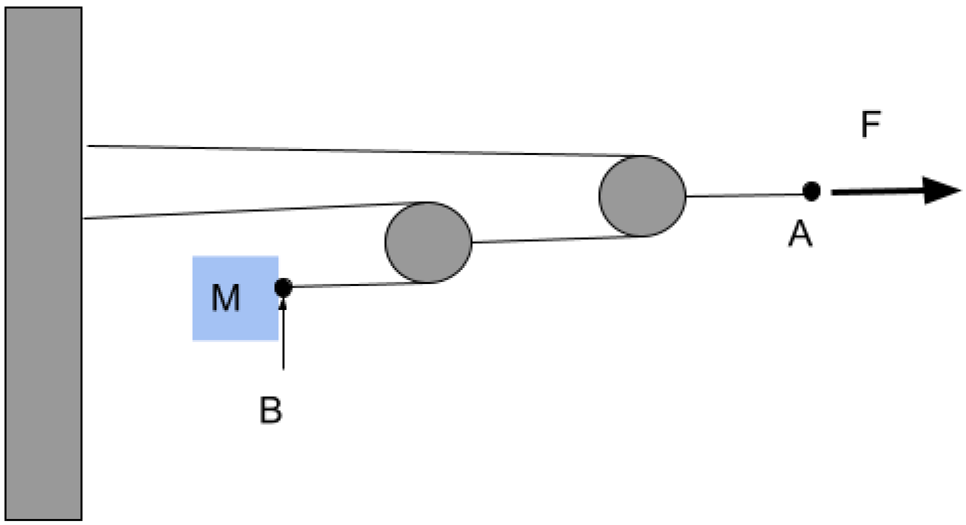
Common errors in b)

- Thinking that one normal mode has the same characteristic frequency as the others
- Finding the sqrt of the magnitude of the normal vector to solve for the effective spring constant. The force on a single mass (which gives you the effective spring constant) is not equal to the k*sum of the initial displacements - you can see this by drawing a free body diagram.
- Using -K instead of K and getting an imaginary frequency

Comment Exam problem 14
Graded by Alex Merrill

Generally the first 4 parts of this problem (b-e) were supposed to be straightforward. The majority of the students did quite well on these. They were relatively easy to solve with basic FBDs, Though there were some issues

- People either assume the acceleration of the force, $a_A = a_B$ or misread the question and solved for $a_B = F/4m$. If you did that your diagram looked like this



- Some people did not understand that the force is always applied to the right and that except for part b., the mass is moving to the right as well
- Some people used extraneous pulleys to redirect the rope. Parts B-D required 1 pulley and E required 2.

Part F, This part was much harder and it showed, and in fact this question could not be exactly solved in 1d

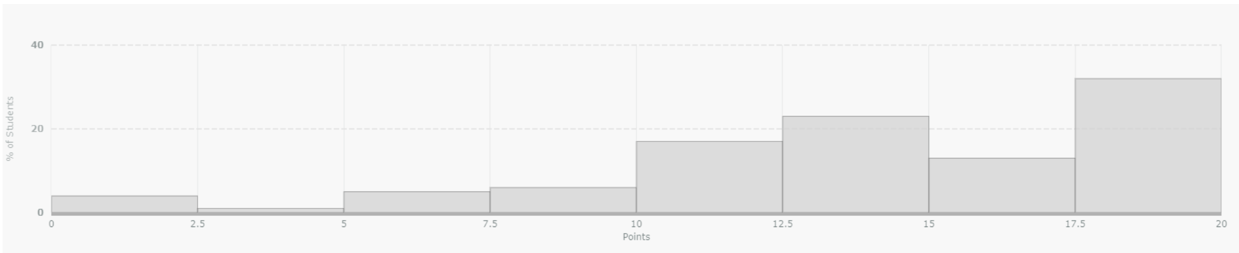
- Many people either misinterpreted the question, or equated acceleration and got the same answer from part c., see solutions for more detail.
- If people realized that the answer from C. was incorrect they usually ended up with a correct approximation.
- Furthermore some people drew a correct approximation, but did not come up with any justifications, which usually meant you lost a few points.

Overall:

- Watch out for the subscripts, this got a lot of people on parts D. and F.
- Other people said that $a_A = a_b$ That is a poor assumption, because when pulleys multiply forces they also ALWAYS involve length relations which means distances are multiplied.
- FBDs were pretty good in general.

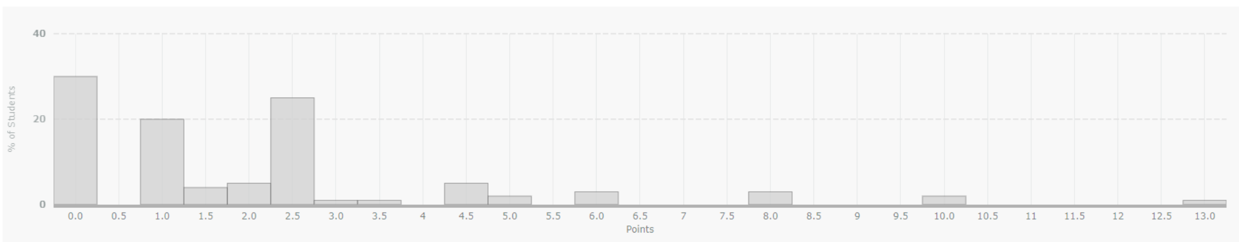
- People in general didn’t write much and given the context of the question was allowable from a grade perspective (except in part F) however I think had some people done out some work it would have allowed them to fix mistakes.

Histograms Part B-E



MINIMUM	MEDIAN	MAXIMUM	MEAN	STD DEV
2.0	14.0	20.0	13.76	4.74

Histogram Part F



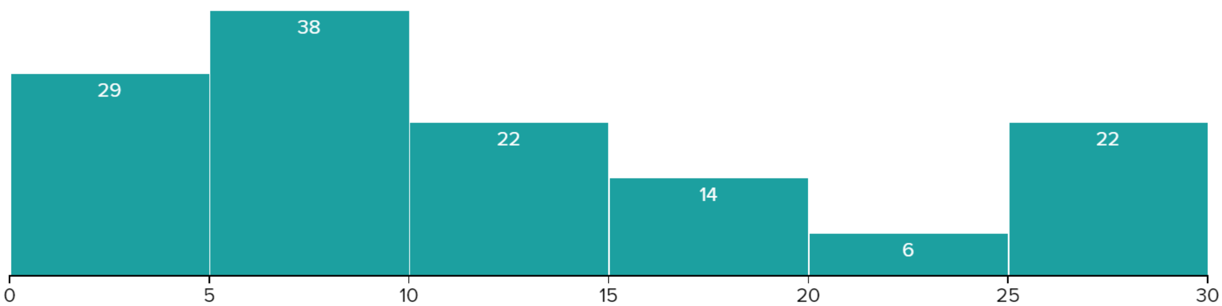
MINIMUM	MEDIAN	MAXIMUM	MEAN	STD DEV
0.0	1.25	13.0	2.02	2.34

MAE 2030 Problem 15 Comments

Graded by Ning Ting Ni (nn255)

This problem was definitely hard to grade because you either know how to solve it or you don't, hence either low scores or high scores. The problem is primarily dependent on certain concepts, which means it is hard to get it right if you don't fully understand the setup (and its individual terms).

Here is the grade distribution:



MINIMUM	MEDIAN	MAXIMUM	MEAN	STD DEV
1.0	9.0	35.0	12.31	9.44

A lot of students used Linear Momentum Balance/Angular Momentum Balance, which would be completely wrong. This is a purely kinematics problem, meaning that you are concerned with the motion of the object rather than the forces that cause the motion. You probably figured out you have to break the problem into the individual bars. Even if you apply AMB or LMB, you'd have to relate the velocity of the two bars, which would involve using reference frames (and I believe you are not given enough information to solve it using AMB/LMB). This is how you know you should use relative motion for this problem.

Other overall issues:

- Problems with dot products and signs
- **Confusion with reference frames vs points!!**
    - Subscripts in relative motion equations (which adds to confusion when trying to substitute in terms)

If you did figure out you need to solve it using relative motion, here are some main issues for part a:

- Assuming that ω_E is the same as ω_{BD}
    - it ended up being the same! But you need to assume it is different until you come to that conclusion
- Not attempting $\overline{v_D} = \overline{v_D}$

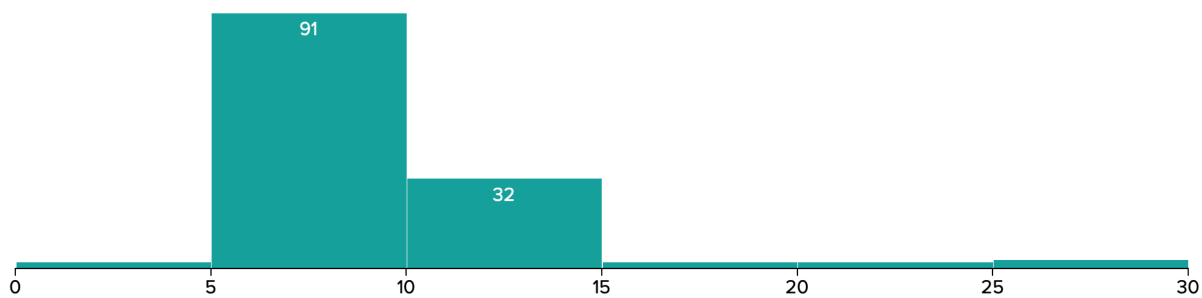
- ○ Needed to find ω_E!
- Using $(H - r)$ for $\overline{r}$ in $\overline{v_E}$ equation
    - ○ This is primarily related to the wrong interpretation of the relative motion formula. A lot of students attempted: $\overline{v_E} = \overline{v_D} + \overline{v_{D/E}}$, which is where you would've gotten the $(H - h)$ from. But they forgot to evaluate $\overline{v_D} = \overline{v_A} + \overline{v_{D/A}}$. This would cancel out the h term, leaving you with $\overline{v_E} = \omega\hat{k} \times H\hat{j}$
- Students left answers unsimplified or in terms of $\hat{i}$ and $\hat{j}$ (i.e. $\hat{r}$,θ)
    - ○ Many students understood that $h = Lsin\theta$ and $d = Lcos\theta$ but did not apply that to the final answer. This would've put the answers in terms of d and h and not θ

For part b, this is a setup question so I gave students extra points for actually solving it! Pretty similar issues to part a:

- Assuming that α_E is the same as α_{BD}
    - ○ Did not end up being the same this time!
- Not attempting $\overline{a_D} = \overline{a_D}$
- Using $(H - r)$ for $\overline{r}$
    - ○ Same reason as part a above
- If you used relative motion (5 term acceleration) in the $\overline{a_D} = \overline{a_D}$ analysis, a lot of students left out the $2\overline{\omega_{frameA}} \times \overline{v_{D/frameA}}$ term for bar AE. Possible reasons may be:
    - ○ Mistaken $v_{D/frameA}$ as $v_{D/A} = 0$

MAE2030 Final Exam p16
Graded by Katherine Cao

Class Performance:



MINIMUM	MEDIAN	MAXIMUM	MEAN	STD DEV
3.0	8.0	30.0	8.99	4.29

Common Mistakes:
Related to Problem Prompt:
Included gravity.
Misunderstood $\ddot{r}$, such as instant acceleration at the contact point.

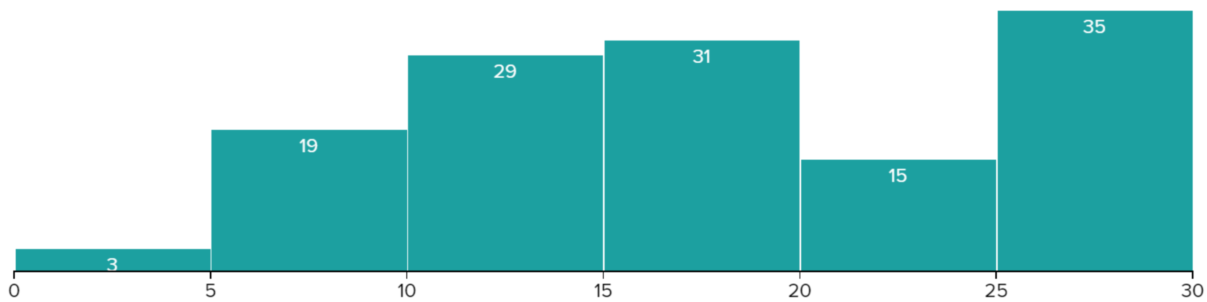
Related to Rolling:
Assuming Friction $f = \mu N$ all the time, instead of μ being large enough to always provide the friction force needed. This led to:
-marked friction force incorrectly in FBD.
-not actually taking rolling condition into consideration (no rolling condition equation listed).
-using only LMB to solve for $\ddot{r}$.
-incorrect friction force in AMB or/and LMB.

Related to Acceleration:
Conceptual erros regarding kinematics:
-Made errors when using 5-term acceleration.
-Zeroed out wrong term using polar coordinates.
Confused arm rotation and disk rolling velocity/acceleration.

Other:
Calculated moment of inertia though given.

Review Grades for **Final Problem 5 (Problem 17 Overall)**

● **REGRADE REQUESTS OPEN** ● **GRADES PUBLISHED**



MINIMUM	MEDIAN	MAXIMUM	MEAN	STD DEV
2.0	**16.0**	**32.0**	**17.42**	**7.81**

1. The first common mistake is that people choose to do AMB about point G, which is okay, but they assume that the force on point D is:

   $\vec{F} = m\vec{a}_D$ or $F_x = ma_{Dx}, F_y = ma_{Dy}$

   While in fact, the force should be calculated using LMB, which is:

   $\vec{F} = m\vec{a}_G$

   And the acceleration should be:

   $\vec{a}_G = \vec{a}_D + \vec{a}_{G/D}$ or $\vec{a}_{G/\mathcal{F}} = \vec{a}_{D/\mathcal{F}} + \vec{a}_{G/D}$

   which means that $\vec{a}_{G/\mathcal{F}} = \vec{a}_G$ unless it is otherwise specified.

   Then, the important step is to figure out what $\vec{a}_{G/D}$ is.

2. The second common mistake is that people use five-term formula for acceleration but do not really understand what the moving body frame $\mathcal{B}$ is, what $\vec{\omega}$ is in the formula, or what each term means.

   There are two ways to specify the moving frame. For instance, if you specify the moving body frame as translating with point D, then the body frame is not spinning and $\vec{\omega}$ would be zero in this case. In other words, $\vec{\omega}$ is not necessarily $\dot{\theta}\hat{k}$ and it depends on how you define $\vec{\omega}$ and $\dot{\theta}\hat{k}$.

   On the other hand, if you specify the moving frame $\mathcal{B}$ as rotating with the pendulum, then $\vec{\omega} = \dot{\theta}\hat{k}$ but $\vec{a}_{G/\mathcal{B}}$ and $\vec{v}_{G/\mathcal{B}}$ would be 0 in this case.

3. Many students did not write the AMB equation correctly. If you were doing AMB about point G, the correct equation should be $\vec{M}_{/G} = \vec{r}_{G/G} \times m\vec{a}_G + I^G\ddot{\theta}\hat{k}$, where $\vec{r}_{G/G} = \vec{0}$.

And if you did AMB about point D, the correct equation should be:

$\vec{M}_{/D} = \vec{r}_{G/D} \times m\vec{a}_G + I^G \ddot{\theta}\hat{k}$

Notice that D always appears on the right of "/" in the equation.

4. Other general comments:
   - People forgot to draw FBD
   - People tried to use $\vec{v}_D$ but that is not needed for this problem
   - People confused about how to compute acceleration, which should be:

   $\vec{a}_G = \vec{a}_D + \vec{a}_{G/D}$ or $\vec{a}_{G/\mathcal{F}} = \vec{a}_{D/\mathcal{F}} + \vec{a}_{G/D}$

   Namely, $\vec{a}_{G/\mathcal{F}} = \vec{a}_G$ unless it is otherwise specified. You can also use five-term formula but you need to be very careful with the moving frame (refer to the second comment).