

**Allowed Materials:** F.E. approved calculator(s) see syllabus; pencil and/or pen.

ExamForm := 21

**Honor Statement:** On my honor, I promise that I have not received any unauthorized assistance on this exam (I didn't look at another student's paper, I didn't view any unauthorized written materials, I didn't talk or listen to another student, I didn't use an unauthorized calculator, I did not use any electronic device to exchange information with others.) I have maintained the highest standards of academic integrity while completing this exam.

Signed: \_\_\_\_\_



**0. (5 point deduction for failure to complete this problem!)**

- Write in all of the indicated information in the boxes of your response form.
- Darken the appropriate circles to encode the corresponding information.
- Write your name on this exam and sign the Honor Statement.

**Bubble:** For Course Section:

91	H01 - Crittenden TR 10-11:50
92	H02 - Reeves TR 2-3:50
93	H03 - Swanbom TR 12-1:50
94	H04 - Moller TR 8-9:50
01	001 - Swanbom MW 2-3:50
02	002 - Moller TR 12-1:50
03	003 - Reeves TR 8-9:50
04	004 - Easley TR 2-3:50

**Notes:**

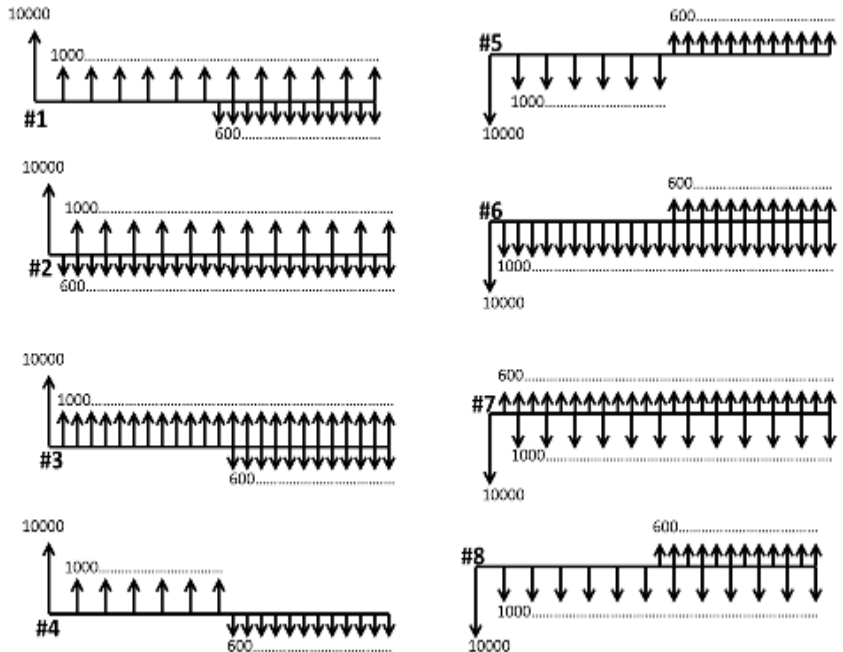
- If your last name is too long, just write the first 10 letters.
- "F.I." and "M.I." are your first and middle initials, respectively
- Your "Username" is the first part of your LATech email address
- For "Section" use the guide provided to the right
- Your "Exam Form" is printed on the upper right corner of this page.
- Indicate "ENGR" as the "Program"

Last Name										F.I.	M.I.	LA Tech Username					Course #	Section (last 2 digits)
(A)	(A)	(A)	(A)	(A)	(A)	(A)	(A)	(A)	(A)	(A)	(A)	(A)	(A)	(A)	(A)	(A)	(0)	(0)

Exam Form	Program
<input type="radio"/>	BIEN
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<input type="radio"/>	CYEN
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1. (3 points) Your rich aunt Sarah Belle just gave you \$10,000. She plans to give you an additional \$1000 at the end of every other month for the next 2 years. You plan to invest all this money at 4% interest. Unfortunately, after a year, your mom plans to kick you out of her basement because you are receiving so much cash from her sister. Therefore at that time you will start paying \$600 rent at the end of every month, which you will draw from the investment. Which cash flow diagram represents the perspective of the investment over the 3-year time period described?



- Choices =
- "A" "#3"
  - "B" "#7"
  - "C" "#4"
  - "D" "#1"
  - "E" "#5"
  - "F" "#2"
  - "G" "#6"
  - "H" "#8"



2. (3 points) According to the notes, a learning persona likes to gather new sources of information. Which of the following is a learning persona?

Choices =

"A"	"Set Designer"
"B"	"Caregiver"
"C"	"Collaborator"
"D"	"Cross-Pollinator"
"E"	"Story Teller"
"F"	"Director"
"G"	"Experience Architect"
"H"	"Hurdler"



3. (3 Points) Which statements are true of uniform series (A), when applying the formulas given in the class notes?

1. The first payment occurs at time zero.
2. The first payment occurs at time 1.
3. It doesn't matter when the first payment occurs.
4. The last payment occurs at time "n"
5. The last payment occurs at time "n-1"
6. It doesn't matter when the last payment occurs.

Choices =

"A"	"1 and 6"
"B"	"1 and 5"
"C"	"2 and 5"
"D"	"3 and 5"
"E"	"2 and 4"
"F"	"3 and 4"
"G"	"3 and 6"
"H"	"2 and 6"
"I"	"1 and 4"
"J"	"All six"



4. (3 points) Which of the following expressions would provide the future value (F) of an investment made today (P) at an annual interest rate (i) after (n) years, if the interest is compounded continuously (i.e. an infinite number of times per year)?

1: $F = P \cdot (1 + i)^n$	4: $F = \lim_{x \rightarrow \infty} \left[ P \cdot \left( 1 + \frac{i}{x} \right)^{n \cdot x} \right]$
2: $F = P \cdot \left( 1 + \frac{i}{12} \right)^{n \cdot 12}$	5: $F = \lim_{i \rightarrow \infty} \left[ P \cdot (1 + i)^n \right]$
3: $F = \lim_{x \rightarrow \infty} \left[ P \cdot \left( 1 + \frac{i}{x} \right)^n \right]$	6: $F = \lim_{n \rightarrow \infty} \left[ P \cdot (1 + i)^n \right]$

Choices =

"A"	"6"
"B"	"3"
"C"	"4"
"D"	"2"
"E"	"5"
"F"	"1"



5. (3 points) To the right is a partial listing of specifications for a particular accelerometer. If the x-axis is pointed upward, what is the smallest upward acceleration that will cause the accelerometer to output its highest value?

Series	-
Axis	X, Y, Z
Acceleration Range	$\pm 3.6g$
Sensitivity	300mV/g
Voltage - Supply	1.8 V ~ 3.6 V
Output Type	Analog
Bandwidth	1.6kHz - XY, 550Hz - Z
Interface	-
Mounting Type	Surface Mount
Package / Case	16-LQFN Exposed Pad, CSP
Supplier Device Package	16-LFCSP-LQ (4x4)

*Hint: Consider the output when the accelerometer is stationary in this position.*

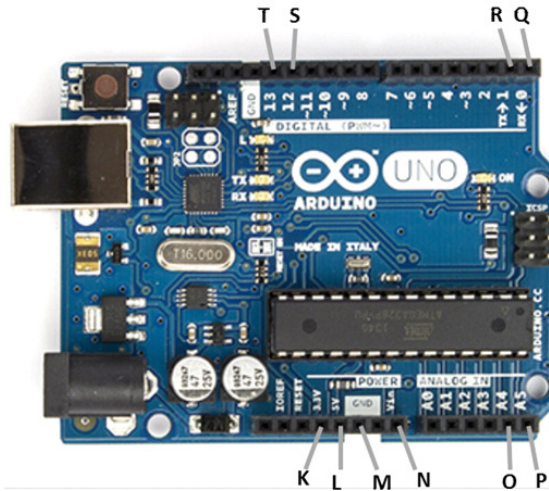
Choices =

"A"	"-1.6g"
"B"	"-3.6g"
"C"	"2.6g"
"D"	"1.6g"
"E"	"-2.6g"
"F"	"-4.6g"
"G"	"0"
"H"	"3.6g"
"I"	"g"
"J"	"3g"

6. (3 points) The table shown is from the specifications sheet for a laser-based distance sensor. Based on the information in the table, which Arduino pin would you wire to the sensor's Pin 4?

Pin	Name	Type	Function
1	GND	G	System ground. Connect to power supply's ground (GND) terminal.
2	VCC	P	System power, 5 VDC input.
3	SOUT	O	Serial output <b>to</b> host. 5 V TTL-level interface, non-inverted, 8 data bits, no parity, 1 stop bit, baud rate matched to host.  Note: The LRF Module hardware design provides bidirectional communication capability for the SOUT pin. This allows the use of a standard three-pin servo extension cable (Parallax #805-00001) for connecting the LRF Module to the host. However, bidirectional communication requires changes to the LRF Module firmware, not currently supported by Parallax.
4	SIN	I	Serial input <b>from</b> host. 3.3 V to 5 V TTL-level interface, non-inverted, 8 data bits, no parity, 1 stop bit, baud rate matched to host.

- Choices =
- "A" "M"
  - "B" "R"
  - "C" "L"
  - "D" "K"
  - "E" "T"
  - "F" "N"
  - "G" "Q"
  - "H" "P"
  - "I" "O"
  - "J" "S"



7. (3 points) You need to select a pressure sensor for use with the Arduino Uno. You want the one that can be directly powered by the Arduino's voltage regulator, and whose output signal can be directly read, without modification, by the Arduino's analog input. You need to collect readings only under ordinary operation of your system, which will not exceed 20 PSI, but your sensor must be able to withstand occasional surges as high as 55 PSI. Which part number will you choose?

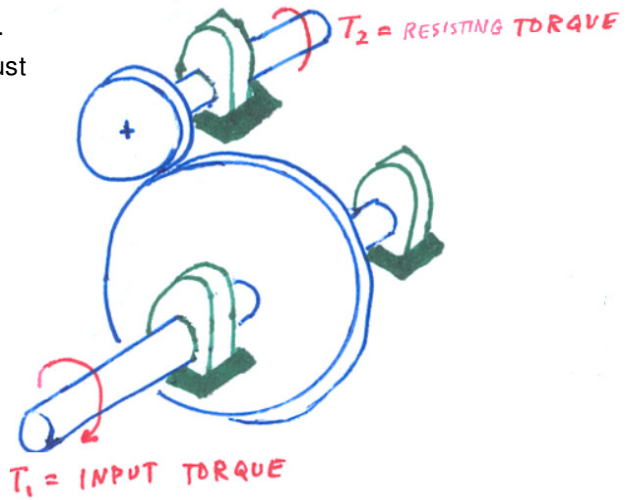
Part Number	Supply voltage	Output signal	Operating range	Maximum Pressure
5-25-ma	5VDC	4mA-20mA	0-25 PSI	40 PSI
5-50-ma	5VDC	4mA-20mA	0-50 PSI	60 PSI
5-25-v	5VDC	0V-5V	0-25 PSI	40 PSI
5-50-v	5VDC	0V-5V	0-50 PSI	60 PSI
12-25-v	12VDC	0V-5V	0-25 PSI	40 PSI
12-50-v	12VDC	0V-5V	0-50 PSI	60 PSI
120-25-ma	120VAC	4mA-20mA	0-25 PSI	40 PSI
120-50-ma	120VAC	4mA-20mA	0-50 PSI	60 PSI
120-25-v	120VAC	0V-5V	0-25 PSI	40 PSI
120-50-v	120VAC	0V-5V	0-50 PSI	60 PSI

- Choices =
- "A" "None of these"
  - "B" "120-25-ma"
  - "C" "12-25-v"
  - "D" "120-25-v"
  - "E" "5-50-v"
  - "F" "5-25-ma"
  - "G" "5-25-v"
  - "H" "5-50-ma"
  - "I" "12-50-v"
  - "J" "120-50-v"

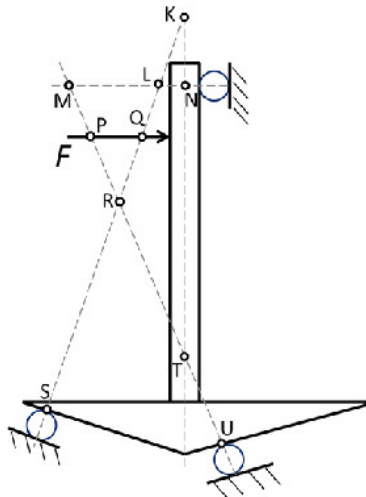
8. (3 points) Gear 1 has three times the number of teeth as Gear 2. Input torque  $T_1$  is applied to the shaft of gear 1 clockwise as shown. For the system to be in static equilibrium, the resisting torque  $T_2$  must be equal to

- Choices =
- "A" "zero"
  - "B" "three times  $T_1$  (CW)"
  - "C" "one-third of  $T_1$  (CW)"
  - "D" "one-third of  $T_1$  (CCW)"
  - "E" "Not enough information"
  - "F" "three times  $T_1$  (CCW)"

Note: CW means "clockwise" and CCW means "counter-clockwise."



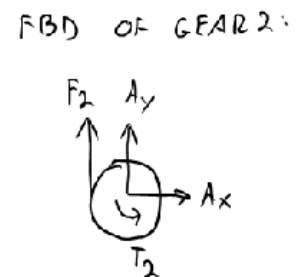
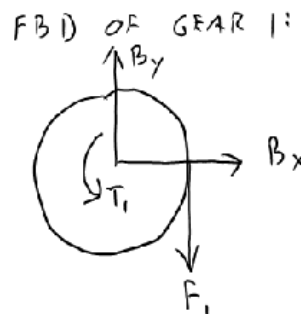
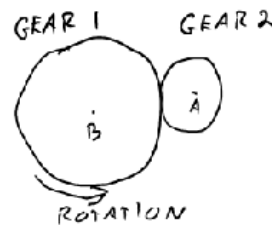
9. (3 points) Assume that the force "F" is known, as well as the weight of the symmetric object. If you want to find the reaction of the roller support at U by means of a single equation, which point must you use a reference point for summation of moments?



- Choices =
- "A" "S"
  - "B" "Q"
  - "C" "T"
  - "D" "M"
  - "E" "R"
  - "F" "U"
  - "G" "N"
  - "H" "K"
  - "I" "L"
  - "J" "P"

10. (3 Points) Assuming that the diagram is drawn to scale and that the gears operate at constant speed, what can be said about the forces  $F_1$  and  $F_2$ ?

- Choices =
- "A" " $F_1 \ll F_2$ "
  - "B" " $F_1 \gg F_2$ "
  - "C" " $F_1 = 0 = F_2$ "
  - "D" " $F_1 > F_2$ "
  - "E" " $F_1 < F_2$ "
  - "F" " $F_2$  is backward"
  - "G" " $F_1 = F_2$ "
  - "H" " $F_1$  and  $F_2$  backward"
  - "I" " $F_1$  is backward"
  - "J" "Nothing can be said"

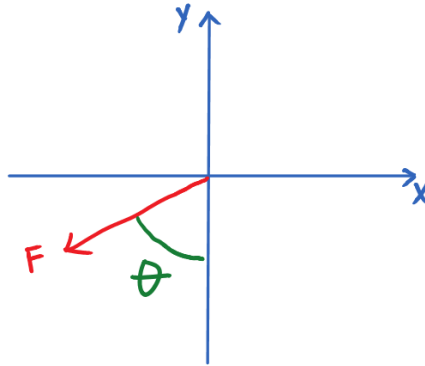




11. (5 points) The y-component of the force depicted below is closest to:

$$F = 280 \cdot \text{lbf}$$

$$\theta = 58 \cdot \text{deg}$$



Choices =

"A"	-118.7
"B"	-148.4
"C"	-237.5
"D"	-296.8
"E"	-474.9
"F"	118.7
"G"	148.4
"H"	237.5
"I"	296.8
"J"	474.9

·lbf



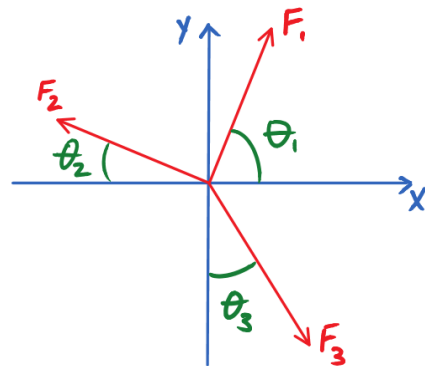
12. (5 points) The angle of the resultant of the three forces depicted below is closest to:

$$F_1 = 40 \cdot \text{lbf} \quad F_2 = 36 \cdot \text{lbf} \quad F_3 = 56 \cdot \text{lbf}$$

$$\theta_1 = 65 \cdot \text{deg} \quad \theta_2 = 25 \cdot \text{deg} \quad \theta_3 = 30 \cdot \text{deg}$$

**NOTE:**

the measure of the angle should be considered from the positive x axis and is limited from -180 deg to 180 deg



Choices =

"A"	-13.6
"B"	-52.2
"C"	-76.4
"D"	-103.6
"E"	-166.4
"F"	13.6
"G"	52.2
"H"	76.4
"I"	103.6
"J"	166.4

·deg

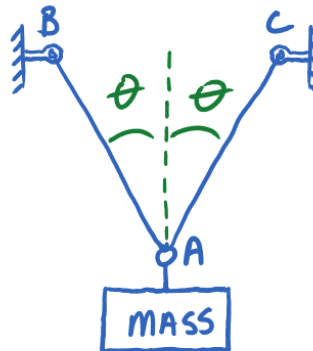


13. (5 points) A mass is suspended by two ropes of equal length (AB and AC). The tension in rope AC is closest to:

$$\text{mass} = 22.6 \cdot \text{kg}$$

$$\theta = 22 \cdot \text{deg}$$

$$g = 9.81 \frac{\text{m}}{\text{s}^2}$$



Choices =

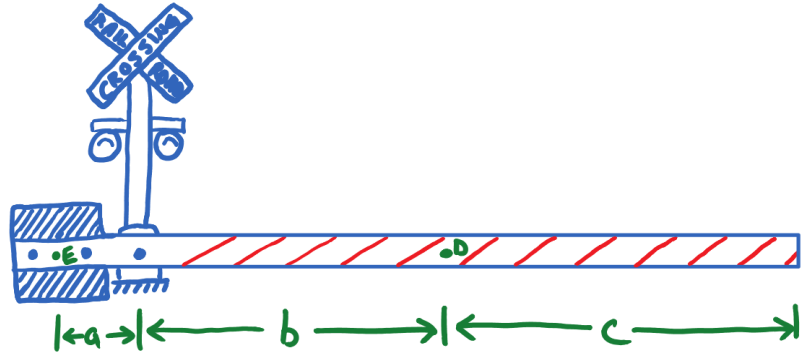
"A"	114.7
"B"	119.6
"C"	124.5
"D"	129.3
"E"	134.3
"F"	139.2
"G"	144.0

·N



14. (5 points) The railroad crossing gate's beam has a center of gravity at point D. A counterweight with a center of gravity at point E is attached to the left side of the crossing gate's beam. If the beam is perfectly balanced at the pin on the signpost when the beam's  $\text{weight}_{\text{beam}} = 81 \cdot \text{lbf}$ , the counterweight's force is closest to...

- Choices =
- |     |     |
|-----|-----|
| "A" | 549 |
| "B" | 579 |
| "C" | 608 |
| "D" | 638 |
| "E" | 666 |
| "F" | 695 |
| "G" | 726 |
| "H" | 755 |
| "I" | 785 |
| "J" | 814 |
- lbf



$$a = 2.1 \cdot \text{ft} \quad b = 15 \cdot \text{ft} \quad c = 21 \cdot \text{ft}$$

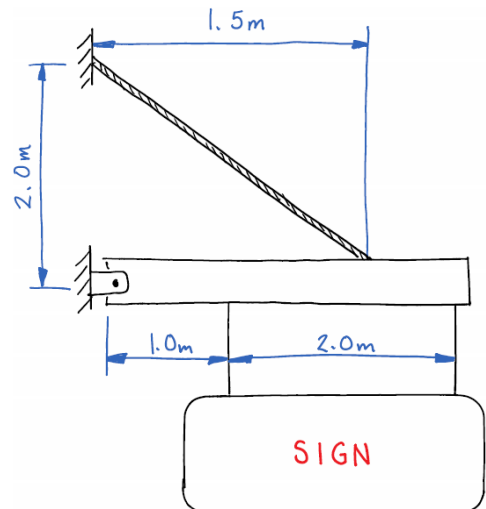
Note: Graphic may not be drawn to scale



15. (5points) A sign hangs from two cables that are attached to a beam as shown below. The beam is supported by a pin and a cable. The tension in the cable is closest to:

- Choices =
- |     |       |
|-----|-------|
| "A" | 490.5 |
| "B" | 515.3 |
| "C" | 540.3 |
| "D" | 565.5 |
| "E" | 590.5 |
| "F" | 615   |
| "G" | 639.4 |
| "H" | 665.6 |
| "I" | 689.7 |
| "J" | 713.8 |
- N

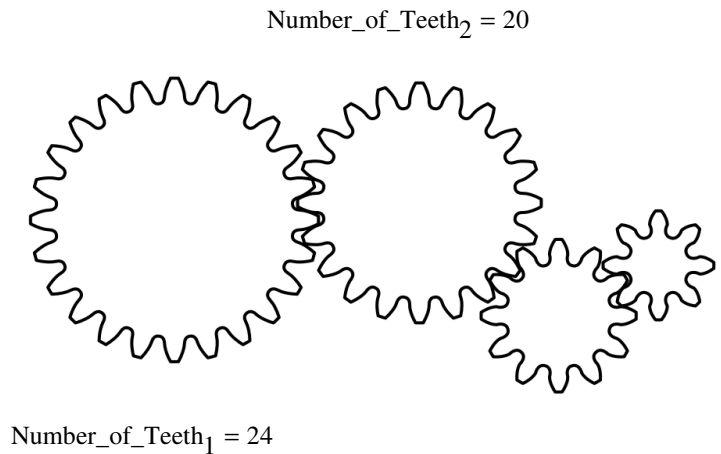
$$\text{Sign\_Mass} = 30 \text{ kg}$$





16. (5 points) Four spur gears mesh together as shown below. If the largest gear spins at 200 RPM, and transmits  $T_1 = 32 \cdot \text{ft} \cdot \text{lbf}$  of torque, the Torque transmitted by the smallest gear is closest to:

Choices =  $\left( \begin{array}{l} \text{"A"} \quad 9.6 \\ \text{"B"} \quad 10.1 \\ \text{"C"} \quad 10.7 \\ \text{"D"} \quad 11.2 \\ \text{"E"} \quad 11.7 \\ \text{"F"} \quad 12.3 \\ \text{"G"} \quad 12.8 \\ \text{"H"} \quad 13.4 \\ \text{"I"} \quad 13.9 \\ \text{"J"} \quad 14.4 \end{array} \right) \cdot \text{ft} \cdot \text{lbf}$

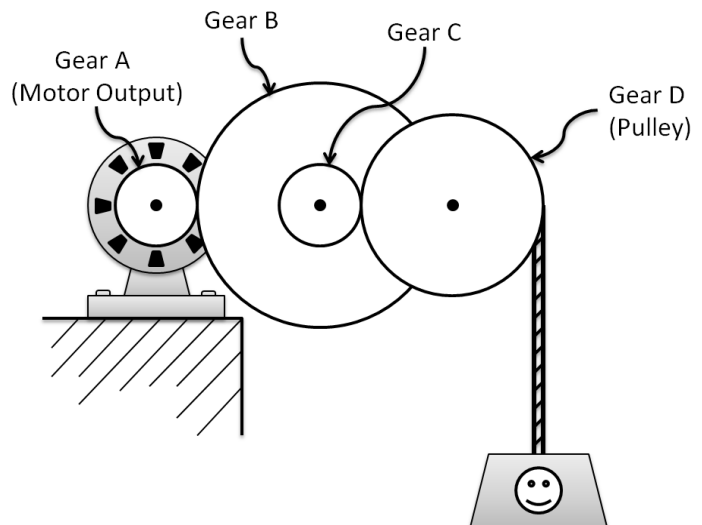


17. (5 points) Four spur gears mesh together as shown below. Gears B and C are stacked together to form a compound gear. Gear D also has a pulley (diameter = 18-in) attached to it that winds a rope attached to a weight. If Gear A spins at  $\text{RPM}_A = 122 \cdot \text{rpm}$ , then the weight lifts at a rate closest to:

Choices =  $\left( \begin{array}{l} \text{"A"} \quad 24.4 \\ \text{"B"} \quad 26.7 \\ \text{"C"} \quad 29.0 \\ \text{"D"} \quad 31.3 \\ \text{"E"} \quad 33.7 \\ \text{"F"} \quad 36.0 \\ \text{"G"} \quad 38.3 \\ \text{"H"} \quad 40.7 \\ \text{"I"} \quad 43.0 \\ \text{"J"} \quad 45.3 \end{array} \right) \cdot \frac{\text{in}}{\text{s}}$

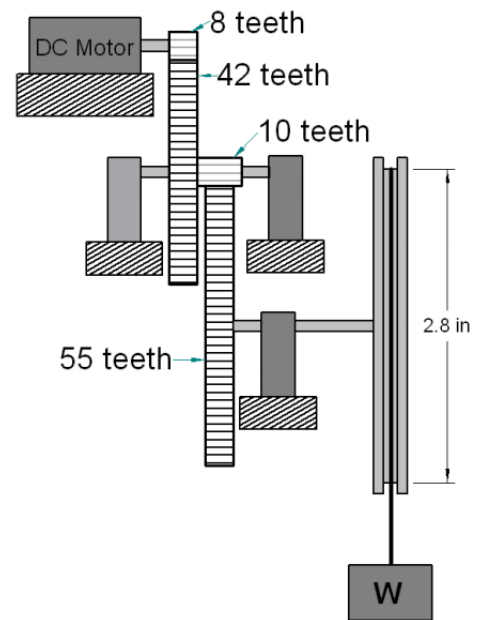
Number of Teeth on each gear:

GearA = 24  
GearB = 48  
GearC = 24  
GearD = 36



18. (5 points) A DC motor is supplied with 5 Volts and draws a current = 1.1 A while lifting a weight = 700-gram mass as shown in the diagram below. The weight is lifted 50 cm in 4 seconds. The efficiency of the system is closest to:

- Choices =
- |     |        |
|-----|--------|
| "A" | 4.604  |
| "B" | 6.168  |
| "C" | 7.75   |
| "D" | 9.323  |
| "E" | 10.879 |
| "F" | 12.461 |
| "G" | 14.037 |
| "H" | 15.607 |
| "I" | 17.176 |
| "J" | 18.752 |
- .%







19. (5 points) Kay borrowed money (  $\text{loan} = \$5000$  ) and agreed to repay the entire amount owed at the end of five years. If Kay's repayment is based on an  $\text{interest\_rate} = 10\%$  simple annual interest, the total amount she owes after five years is closest to:

Choices =  $\left( \begin{array}{l} \text{"A"} \text{ } \$2500 \\ \text{"B"} \text{ } \$6895 \\ \text{"C"} \text{ } \$7500 \\ \text{"D"} \text{ } \$5079 \\ \text{"E"} \text{ } \$500 \\ \text{"F"} \text{ } \$6288 \\ \text{"G"} \text{ } \$5686 \end{array} \right)$



20. (5 points) Danny borrowed money (  $\text{loan} = \$1000$  ) and agreed to repay the entire amount owed at the end of two years. If Danny's repayment is based on an  $\text{interest\_rate} = 7\%$  per year, compounded annually, the amount he owes after two years is closest to:

Choices =  $\left( \begin{array}{l} \text{"A"} \text{ } \$1490 \\ \text{"B"} \text{ } \$1070 \\ \text{"C"} \text{ } \$930 \\ \text{"D"} \text{ } \$799 \\ \text{"E"} \text{ } \$1145 \\ \text{"F"} \text{ } \$972 \\ \text{"G"} \text{ } \$1490 \end{array} \right)$



21. (5 points) Janice pays her electricity bill annually. Based on the bill she just paid, she expects her upcoming electricity bill to have a total  $\text{cost} = \$1000$  . Based on her analysis of previous electricity bills, she expects an annual  $\text{inflation\_rate} = 2\%$  on each utility bill after the upcoming one. (This means each successive bill will be 2% higher than the one before it.) If you assume Janice's money holds an  $\text{interest\_rate} = 5\%$  per year, compounded annually, the present worth of her electricity bills for the next five years is closest to:

Choices =  $\left( \begin{array}{l} \text{"A"} \text{ } \$4039 \\ \text{"B"} \text{ } \$4497 \\ \text{"C"} \text{ } \$3351 \\ \text{"D"} \text{ } \$4269 \\ \text{"E"} \text{ } \$3810 \\ \text{"F"} \text{ } \$4724 \\ \text{"G"} \text{ } \$3587 \end{array} \right)$



22. (5 points) Neil has an annuity that guarantees an  $\text{interest\_rate} = 5\%$  per year, compounded annually on his investments. If Neil's  $\text{investment} = \$10000$  per year for 20 consecutive years, the value of the account at the time of the last investment is closest to:

Choices =  $\left( \begin{array}{l} \text{"A"} \text{ } \$430578 \\ \text{"B"} \text{ } \$397437 \\ \text{"C"} \text{ } \$330660 \\ \text{"D"} \text{ } \$464098 \\ \text{"E"} \text{ } \$364023 \\ \text{"F"} \text{ } \$297357 \\ \text{"G"} \text{ } \$200000 \end{array} \right)$



23. (5 points) Sally is going to invest at a  $\text{initial\_deposit\_rate} = \$200$  per month for twenty years (i.e., years 1-20) and a  $\text{subsequent\_deposit\_rate} = \$300$  per month for the next ten years (i.e., years 21-30). After this period of time, Sally plans to withdraw an equal amount each month for a twenty year time period (i.e., over years 31-50). If Sally can earn a minimum  $\text{interest\_rate} = 1\%$  per month, the equal monthly amount she can be sure she could withdraw from the account each month for the final twenty-year period is closest to:

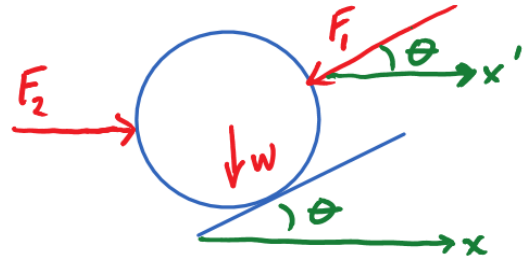
Choices =  $\left( \begin{array}{l} \text{"A"} \text{ } \$7950 \\ \text{"B"} \text{ } \$6352 \\ \text{"C"} \text{ } \$9552 \\ \text{"D"} \text{ } \$7147 \\ \text{"E"} \text{ } \$10354 \\ \text{"F"} \text{ } \$5548 \\ \text{"G"} \text{ } \$8749 \end{array} \right)$



24. (5 points) A barrel of weight  $W$  rests on an inclined surface under the loading conditions shown. The force acting on the barrel from the inclined surface is therefore closest to...

Choices =  $\begin{pmatrix} \text{"A"} & 11.5 \\ \text{"B"} & 12.3 \\ \text{"C"} & 13.2 \\ \text{"D"} & 14.0 \\ \text{"E"} & 14.8 \\ \text{"F"} & 15.7 \\ \text{"G"} & 16.5 \\ \text{"H"} & 17.3 \end{pmatrix} \cdot \text{N}$

$W = 6.8 \text{ N}$   
 $F_1 = 15 \text{ N}$   
 $\theta = 30\text{-deg}$



**Note:** axes  $x$  and  $x'$  are parallel and the center of gravity of the barrel is at its geometric center



25. (5 points) On a certain assembly line in a plant, one of the tasks is to lift a part from a conveyor and place it in a fixture for a welding process. Currently a low-skill laborer who costs the plant \$6,000/month to employ (paid at the end of each month) performs this task. You are considering replacing this laborer with a robot that will cost the plant \$190,000 to purchase and install. You estimate the salvage value of the robot to be \$11,500 whenever the plant stops using it (regardless of how long it is used). The robot is so reliable and robust that you do not plan on having any cost for its upkeep.

In order to help you evaluate how good this investment might be, you want to determine how long it will take to "break even," (i.e. how long it will take for the future value of the proposed investment to be the same as the future value of employing the laborer). Assuming an annual interest rate of  $i = 6.5\%$ , compounded monthly, the amount of time it will take to "break even" is closest to:

Choices =  $\begin{pmatrix} \text{"A"} & 22.8 \\ \text{"B"} & 24.6 \\ \text{"C"} & 26.2 \\ \text{"D"} & 27.9 \\ \text{"E"} & 29.5 \\ \text{"F"} & 31.2 \\ \text{"G"} & 32.9 \\ \text{"H"} & 34.6 \end{pmatrix} \cdot \text{months}$



26. (5 points) Dr. Reeves is planning on opening an Alligator farm, and he is trying to decide whether to set his farm up as a feedlot (a farm that buys hatchling alligators and raises them to adulthood) or as a fully integrated operation (a farm that also breeds Alligators, incubates eggs, and then raises the Alligators to adulthood). Dr. Reeves only wants to spend 20 years as an alligator farmer. The costs and revenues expected for this 20-year investment are shown in the table. The annual interest rate is  $i = 3.5\%$ , compounded monthly.

Item	Feedlot Option			Integrated Operation		
	Amount	Frequency	Timing	Amount	Frequency	Timing
Facilities	-\$90,000	one time	now	-\$120,000	one time	now
Labor	-\$1,000	monthly	starting at the end of 1st month until the end of the 20 year project	-\$1,200	monthly	starting at the end of 1st month until the end of the 20 year project
Energy	-\$600	monthly		-\$650	monthly	
Food	-\$500	monthly		-\$600	monthly	
Medicine	-\$200	monthly		-\$300	monthly	
Stock Purchases	-\$1,200	monthly	starting now, until 24 months before the end of 20 years	-\$2,400	one time	now
Sales	\$6,000	monthly	starting at the end of the 24th month until the end of 20 years	\$6,000	monthly	starting at the end of the 36th month until the end of 20 years
Salvage	\$50,000	one time	at the end of 20 years	\$80,000	one time	at the end of 20 years

The difference in the present value of all of the cash flows associated with the two options is closest to:

$$\text{The\_feedlot\_option\_earns} = \begin{pmatrix} \text{"A"} & 28875.27 \\ \text{"B"} & 30511.97 \\ \text{"C"} & 32149.57 \\ \text{"D"} & 33783.65 \\ \text{"E"} & 35402.93 \end{pmatrix} \cdot \text{dollars\_less\_than\_the\_integrated\_operation}$$

$$\text{The\_integrated\_operation\_earns} = \begin{pmatrix} \text{"F"} & 28875.27 \\ \text{"G"} & 30511.97 \\ \text{"H"} & 32149.57 \\ \text{"I"} & 33783.65 \\ \text{"J"} & 35402.93 \end{pmatrix} \text{dollars\_less\_than\_the\_feedlot\_option}$$

Please write and bubble this Exam Form number on your Response Sheet

ExamForm = 21

Key =

	1
1	"D"
2	"D"
3	"E"
4	"C"
5	"C"
6	"B"
7	"E"
8	"C"
9	"I"
10	"G"
11	"B"
12	"F"
13	"B"
14	"B"
15	"A"
16	"C"
17	"G"
18	"H"
19	"C"
20	"E"
21	"B"
22	"C"
23	"A"
24	"G"
25	"G"
26	"C"

143 ENGR122 Exam 2

ExamForm = 21