Program Assessment Report (PAR)

Biomedical Engineering (BME) Baccalaureate Degree

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ACADEMIC YEAR COVERED BY THIS REPORT: 2020-2021

I. PROGRAM LEARNING OUTCOMES

1. an ability to identify, formulate, and solve complex engineering problems by applying principles of engineering, science, and mathematics 2. an ability to apply engineering design to produce solutions that meet specified needs with consideration of public health, safety, and welfare, as well as global, cultural, social, environmental, and economic factors 3. an ability to communicate effectively with a range of audiences 4. an ability to recognize ethical and professional responsibilities in engineering situations and make informed judgments, which must consider the impact of engineering solutions in global, economic, environmental, and societal contexts 5. an ability to function effectively on a team whose members together provide leadership, create a collaborative and inclusive environment, establish goals, plan tasks, and meet objectives 6. an ability to develop and conduct appropriate experimentation, analyze and interpret data, and use engineering judgment to draw conclusions 7. an ability to acquire and apply new knowledge as needed, using appropriate learning strategies.

II. PROCEDURES USED FOR ASSESSMENT

A. Direct Assessment

Learning Outcomes 1 of 7 Graduates will be able to identify, formulate, and solve complex engineering problems by applying principles of engineering, science, and mathematics Assessment Measure Direct Assessment Means of Measurement Assessment of student artifacts Academic years in which this data is collected (at least once every five years) Every two years, next scheduled for 2019-2020, 2021-2022 Method of Assessment BME 3511 (Fall 2016) BME 3511 Test One Electronic Concepts (Question 2) Decibels a. Express half power point in terms of dB b. Given the ratio of two power ratings P2 / P1 = 96; express the power ratio in dB c. Given the ratio of two voltages V2 / V1 = 36; express the voltage ratio in dB d. Express 1200 milliwatts in dBm BME 3511 Test Two Direct Current

Concepts (Question 7) Equivalent Resistance a. Determine the current through R1 (milliamps) b. Determine the voltage across R1 (Volts) BME 3511 Test Five Power Supplies (Question 4) Transformers Given an ideal transformer (assume 100% efficiency) with primary turns = 9600 and secondary turns = 1200; and voltage primary = 120 VACRMS with output impedance of Z = 8 ohms. a. Calculate Voltage Secondary b. Calculate Current Secondary c. Determine Input Power d. Determine Input Impedance BME 3511 Test Seven Alternating Current Concepts (Questions 1 & 2) Resonant Frequency 1. Refer to Figure A - below a. Calculate the circuit impedance for a frequency of 8000 Hz Express your answer as either a complex impedance or as magnitude & angle. 2. Refer to Figure A - above a. Calculate the resonant frequency(in Hz) BME 4550 (Fall 2017 assessment); BME 3530 (to be used in future assessments) Final exam question Specify a battery (voltage and ampere-hours) suitable for a cardiac pacemaker with the following requirements • Battery life between charges five years • Cardiac voltage pulse amplitude 5 V • Mean pulse 80 bpm • ON time of cardiac pulses 1 ms • Battery conversion efficiency 30% • Load resistance 2 kΩ State which type of heart block constitutes 95% of pacemaker applications and describe the condition. Learning Outcomes 2 of 7 Graduates will be able to apply engineering design to produce solutions that meet specified needs with consideration of public health, safety, and welfare, as well as global, cultural, social, environmental, and economic factors Assessment Measure Direct Assessment Means of Measurement Assessment of student success on marker test items Academic years in which this data is collected (at least once every five years) Every two years, next scheduled for 2018-19, 2020-2021, 2022-2023 Method of Assessment BME 4421 Homework problem (Spring 2016) Design a Couette type viscometer, i.e. an inner solid cylinder inside of an outer "hollow" cylinder, with the test fluid in the space between the cylinders as in the following diagram. Either the inner or outer cylinder can rotate; this will have some effect on velocity and, therefore, shear rate. In this design, assume that the inner cylinder rotates. Specifications Sample Volume 20 mL = 20 cm3 Shear Rate Range 0.1 to 100 s-1 Fluid Viscosity Range 1 to 1000 cp = 0.01 to 10 g/(cm·s) = 0.001to 1.00 kg/(m·s) Gap Width < (Ri /10) but > (Ri /50) Bottom Gap Height > (Ri /10) but not too large or much of the sample will not be in contact with the cylinder sides. In general, the device is neither short and wide nor tall and thin. In fact the inner cylinder dimensions could be similar the sketch above, but not the outer cylinder, since this would result in too large a sample. Ignore the top and bottom surfaces in calculating shear rate and shear stress and resulting torque. Determine, in your design (1)Inner (Ri) and outer (Ro) radii and, therefore, the gap width, all converted to mm (2)Length of the cylinders, Lo and Li, expressed in mm. Verify sample volume in your calculation pages. (3)Rotational speeds to produce range of shear rate given, converted to RPM (4)The high and low torque required for greatest possible range of viscosity and shearrate, i.e., lowest viscosity, lowest shear rate and highest viscosity, highest shear rate. Torque units must be in N·mm. Some of the sample volume will fill the space below the inner cylinder but have the sample just even with the top surface of the inner cylinder as shown. The bottom space is included in the sample volume but ignore the shear and resulting torque due to this portion of the sample (5)After the design computations are completed, verify that that the ratio of the bottomsurface area to the side surface area is between 0.05 and 0.10; (6)Derive a formula relating the viscosity to the torque and geometric factors. BME 4421 Homework problem (Spring 2016) Goal Design a steady flow system that provides room-temperature water to a

test section which simulates part of a vessel. The system will be used in a laboratory environment, and is schematically depicted below. Because the system attempts to simulate blood flow, a water/Xanthan gum solution ($\square$ = 0.0032 kg/(m$\square$ sec), $\square$ = 1050 kg/m3) is used to simulate blood properties. You would like to get the highest flow possible, within the practical limitations of the facility, because the flow can always be reduced by a pinch clamp or closing the valve slightly. Minimally, you would like a flow of 2×10-5 m3/s. To keep flow fluctuations to a minimum, a feed reservoir of 50 L volume is specified. Your design must determine the following variables, either by choice or computation 1. Height difference H between feed and return reservoirs. This variable depends upon the space available and, thus, is chosen rather than computed. 2. The flow rate through the system. 3. Diameter and length of a) tubing from feed reservoir to test section; and b) return tubing. Tubing must be standard size(s) of clear, flexible, plastic tubing that is available at U.S. Plastics Corporation (www.usplastic.com). Within limits, it is better to select, rather than compute, these variables. 4. Shape/size of the feed reservoir. Use a tank size that is also available from U.S. Plastics Corp. Return reservoir size and shape choices are open for your specification. 5. Minimum pump power. Include tubing losses, "minor" losses (see Losses section below) and pumping height. LOSSES Assume the test section loss is given by = + where and are dimensionless constants and is the inlet diameter of the test section, which you can take as the same diameter as the inlet tubing (which, as stated above) you are to determine. In the above expression, is the average velocity and and are density, viscosity, and acceleration due to gravity, respectively. Make any other assumptions you need in order to complete your design, but do include tubing losses for laminar flow given by = where and are length and diameter of the tubing. Verify that laminar flow exists in the tubing from the feed reservoir to the test section, i.e., that Red < 2300, where Red = is the Reynolds number in the tube. Don't consider this to be a strict design criterion. The flow can be reduced by valve at the feed reservoir or variable clamp in the feed tubing, realizing that tubing losses will be higher for turbulent flow. Also consider the contribution of "minor" losses at the exit of the "feed" reservoir tube, entrance to the pump in the "return" reservoir, and the tube exit into the feed reservoir. See White, Chapter 6 Minor or Local Losses in Pipe System (pp. 380-389 in the 8th edition). Note that these minor loss expressions are for turbulent flow and actually may underestimate the minor losses in laminar flow because the term may become small with respect to a term proportional to (see White, Chapter 6 Laminar Flow Minor Losses (pp. 388-389 in the 8th edition). Note the analysis of the feed reservoir/test-section design can be separated from that of the pump/tubing from return to feed reservoir. Of course, the same flow will be going through each section. You will have to assume something in order to start the design. For example, you could assume a certain tube diameter and height, and see what flow rate this could produce. For example, the spigot on the tank usually takes ½" or 5/8" ID (inner diameter) tubing. Standard lab room height is 9' from ceiling to floor, so the difference in reservoir levels has to be somewhat less than this. Program BSBE Learning Outcomes 3 of 7 Graduates will be able to communicate effectively with a range of audiences Assessment Measure Direct Assessment Means of Measurement Assessment of student artifacts Academic years in which this data is collected (at least once every five years) Every two years, next scheduled for 2018-19, 2020-21, 2022-23 Method of assessment BME 4910 (Fall 2016) Evaluation of oral presentation of project proposal BME 4920 (Spring 2017)

Evaluation of Senior Design final presentation Learning Outcomes 4 of 7 Graduates will be able to recognize ethical and professional responsibilities in engineering situations and make informed judgments, which must consider the impact of engineering solutions in global, economic, environmental, and societal contexts Assessment Measure Direct Assessment Means of Measurement Assessment of student artifacts Academic years in which this data is collected (at least once every five years) Every two years, next scheduled for 2019-20, 2021-22 Method of Assessment BME 3212 (Spring 2018) We will review engineering advancements taken place at WSU and BIE Dept via senior design projects. Teams developed X-ray kits for an underdeveloped country. Students visited this country to install, train and test the kits. 1) Use of X-ray kits developed by BME students as engineering solution to help diagnose bone/fractures? 2) Comment on the global demography that does not have access to such diagnostic tools? 3) Perform an economical assessment of the cost and benefit in this specific scenario? 4)Perform engineering analysis of x-rays using concepts from BME/ISE 3212 such as position of the target, velocity of the X-ray, energy, work done for a simple bone (wrist) 5) Comment on the International Standard Organization and governing standards that regulate the radiation emitted by the X-ray equipment and required shielding 6) How you would design a social media site that informs the patients in that part of the world GRADING RUBRIC 1. Includes all appropriate sections (1) Introduction and Objective, (2) Procedure, (3) Results, (4) Discussion and Conclusion. (20 Points) 2. The discussion part should contain a comparison between the plots generated (10 points) 3. Economic and global charts and associated references (15 points) 4. Kinematic/kinetic analysis (30 Points) and 5. Spec and radiation (15) 6. Your suggestions (10 points) BME 4920 (Spring 2018) Assignment This is a group writing assignment; one submission per team is required. Your task is to assess the potential impact of your senior design project under the following four contexts global, economic, environmental, and societal. Assume that your prototype will transition to the marketplace product and that your team is the "company" who will market and support that product. Describe how each of these influences has affected or may affect your engineering design and product life cycle. Begin your paper with a concise yet thorough project description (~200-400 words). Then address each of the four contexts in a separate, focused subsection of your paper (~750-1000 words each). A set of questions related to each context is provided below to jumpstart your thinking. For full credit, you are encouraged to think beyond these sample questions rather than just answering the given questions. [Assignment handout, which has additional details, has been provided]. Learning Outcomes 5 of 7 Graduates will be able to function effectively on a team whose members together provide leadership, create a collaborative and inclusive environment, establish goals, plan tasks, and meet objectives Assessment Measure Direct Assessment Means of Measurement Assessment of student artifacts Academic years in which this data is collected (at least once every five years) Every two years, next scheduled for 2018-19, 2020-21, 2022-23 Method of Assessment BME 4910 (Fall 2016) Term paper assignment Define a project that requires a multi-disciplinary team. Decide what disciplines from engineering are required on the team and plan a set of tasks for the team that utilize those disciplines. You can choose a project that might be utilized for senior design, a practical project of interest to you, or a more "fantastic" project that interests you. You should demonstrate your knowledge of other disciplines and how they can contribute to a team. Originality and creative thinking are encouraged and will be rewarded.

Submit via MS Word document. No PDF files. Use 12 point, Times New Roman font. Double-spaced with standard margins. Design and include appropriate cover page with all relevant information. References are optional. Cite references (if applicable) in the body of your paper. Minimize quotations. 500-750 words of writing/text. Cover page, reference page and any numbering will not be included in the word count. Submit the paper on time to the appropriate pilot drop box. Late papers will receive a score of no more than 75%. Papers in excess of one week late receive a score of zero. BME 4920 (Spring 2017) Advisor evaluation of senior design team project Learning Outcomes 6 of 7 Graduates will be able to develop and conduct appropriate experimentation, analyze and interpret data, and use engineering judgment to draw conclusions Assessment Measure Direct Assessment Means of Measurement Assessment of student artifacts Academic years in which this data is collected (at least once every five years) Every two years, next scheduled for 2019-20, 2021-22 Method of Assessment BME 4550 Lab (Fall 2017) Lab 12 Design and conduct experiments; analyze and interpret data Prelab For this lab, you and your partner(s) must design your own experiment using the Biopac System. The following questions must be turned in at the beginning of Lab 12 as a prelab. Both you and your partner must turn in one prelab with both names on it. 1. What is the hypothesis you would like to test for this lab? 2. What techniques will you be using for the test? (BP, EKG, PULSE, etc) 3. List 2 or more parameters you will be analyzing from the data. (BPM, P-P, Delta t, etc) 4. What are your independent variables? What are their levels? What are the dependent variables? Only 2 independent variables are allowed. Keep the levels to a minimum of 3. For example, if I wanted to test the BPM and blood pressure of a person when they are seated, standing, and lying down, my independent variable would be "Subject Position." The levels are seated, standing, and lying down. My dependent variable (response) would be both the BPM and the blood pressure 5. Give a sample data table that will go in your report here. Lab Report Purpose • Place your hypothesis here Procedure • 3 or more different activities (tasks, situations, etc. These will most likely be your "levels" or "factors") Provide pictures for these tasks • Explain the Set-up (What materials did you use? Did only one person get run or two?) • State the independent and dependent variables, as well as the different levels and factors (see first bullet point).   Data and Results • Data for each "level" must appear in some sort of table • Two or more parameters must be used (response/dependent variables) o BPM o Delta t o Blood pressure o P-P o Etc…. • If you feel graphs would be necessary to illustrate the data further, please place them in this section • Picture of person data collected (EKG, BPM, Stethoscope) • Analysis of the data (within tables, equations, or graphs) o Mean o Standard Deviation o Student t-tests o Etc…… (Please see me if you would like help in this area) • Really make this experiment your own. I am here to help or make suggestions of ways you can make this experiment fun and effective Discussion • What is happening with your data (dependent variable) during the experiment over each of the factors/task? Explain why this happened. What physiologically was going on to create this reaction? Be detailed. • Was your hypothesis supported with the following experiment? Why or why not? • Name some sources of error. • Further "research" or experiments should consider what? (Different dependent variables? Using more subjects? Etc….) Conclusion • Ending remarks on this experience. (You can use personal pronouns here, but avoid them in the other parts of the lab report before the conclusion.) • What did you learn? What was different about this lab than other labs? • What made you

interested in this experiment in the first place? Post-Lab • What were your favorite parts of 4550L/6550L? • How can lab be improved for future students? • Which lab did you think did not support the lecture well and can be cut out for next year? • What was the most challenging part of the labs for this class? • Any other relevant comments about the lab itself, please state in this section. BME 3512 Lab (Spring 2018) Lab 3 Kirchoff's Voltage Law Applied to AC Circuit Phasors Purpose The purpose of this lab is to measure phasors and use them to verify Kirchoff's Voltage Law as applied to AC circuits. Procedure Build the following circuit. Set your function generator to f0 = 1 kHz sine with an amplitude of 2 VP-P. Connect Channel 1 of the oscilloscope to the node marked V1 and Channel 2 to the node marked V2. Make sure that all common (black) leads are connected together to the bottom of the circuit. Verify the correct input voltage of 2 VP-P at V1. 2) Measure the peak-to-peak output voltage at V2; record the value. 3) Display both channels simultaneously on the oscilloscope. Using the vertical cursors, measure the time shift of V2 with respect to V1. It may be useful to adjust the horizontal (time base) sensitivity knob to stretch the waveforms for a more accurate measurement. Record the time difference. Remember, shifts to the right of V1 are negative, and shifts to the left are positive. 4) Compute the phase angle of V2 in degrees by the formula $\phi = 360 \cdot \Delta t \cdot f0$. 5) Write V2 in phasor form. Remember, the amplitude of a phasor is always given as peak volts; not peak-to-peak, so divide your peak-to-peak measurement by two. 6) Connect the oscilloscope to V3 and repeat steps 2-5 to determine V3 in phasor form.   7) Using these node voltage, write phasors for VS, VC, VL, and VR. Specifically VS = V1, VC = V1 – V2, VL = V2 – V3, and VR = V3. Important!! Most scientific/graphing calculators can perform mathematical operations on phasors automatically; but verify that your calculator will accept phase angles in degrees, as some models won't, even in degree mode. Otherwise, convert to rectangular form to perform the difference and then back to phasor, or use an online phasor calculator. 8) Verify that VS = VC + VL + VR by Kirchoff's Voltage Law. If your phasors don't add up, check your measurements and troubleshoot your circuit (or calculator!) if necessary. 9) Repeat the entire experiment at f0 = 4 kHz. Postlab 1) Use LTSPICE to determine all simulated node voltage phasors at f0 = 1 kHz and f0 = 4 kHz. Compare to measured values and comment on any significant disparities. Don't forget to include a 50-ohm resistor in series with the voltage source in simulation, per the lab signal generators. 2) Compute the experimental current phasor I by dividing VR by 330 Ω. Compare this phase angle to the phase angles of VC and VL. Verify that voltage leads current in an inductor, and lags in a capacitor. Learning Outcomes 7 of 7 Graduates will be able to acquire and apply new knowledge as needed, using appropriate learning strategies Assessment Measure Direct Assessment Means of Measurement Assessment of student success on marker test items Academic years in which this data is collected (at least once every five years) Every two years, next scheduled for 2018-19, 2020-21, 2022-23 Method of assessment BME 3211 midterm exam question (Fall 2018) 1- The uniform beam has a mass of 50 kg per meter of length. Compute the reactions at the support O and draw FBD. The force loads shown lie in a vertical plane. (16points) 2- A mechanic pulls on the 13-mm combination wrench with the 140 N force shown. Determine the moment of this force about the bolt center O. Magnitude(N.m) and direction . (4 points) 3- The bridge support structure has a mass of 101.94 kg with center of gravity located midway between A and B. Calculate all the reaction forces and draw FBD if a 3 kN load is applied at the point indicated in the figure. (7 points)

B. Scoring of Student Work

Scoring of assessment items was done using an answer key for marker questions on tests and using a rubric for more subjective assessment items. Scoring was done by the course instructor or by a student grader supervised by the course instructor. More specific information about assessment of learning outcomes is described in detail in Criterion 4 and appendices of the ABET self-study.

C. Indirect Assessment

Course evaluations and exit interviews are used as indirect assessment measures for the BSBE program. Details of assessment of the BSBE program can be found in the ABET self study

III. ASSESSMENT RESULTS/INFORMATION:

Details of assessment and findings can be found in Criterion 4 of the ABET self-study.

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IV. ACTIONS TO IMPROVE STUDENT LEARNING

Assessment data are shared in program committee meetings, and faculty then discuss what, if any, actions to take to improve results. Student outcomes are assessed on an alternating two year schedule. About half of the outcomes are assessed in one year and the other half in the following year. Analysis and change implementation happens in the opposite year. Details of the assessment and review processes are described in detail in the ABET self-study.

V. SUPPORTING DOCUMENTS

Additional documentation, when provided, is stored in the internal Academic Program Assessment of Student Learning SharePoint site.