MECH 261/262:- TOPICS-MEASUREMENTS

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August 27, 2007

- Wheeler and Ganji, all of Chapters 1, 2, 3 and 4. Skip Chapter 5. This was covered in earlier years, maybe it will be, again, later. Chapter 6 is for MECH 262, Statistics only.
- First four pages of Chapter 7, "Experimental Uncertainty", are important. This was not done in winter 2007.
- Chapter 8 is the text treatment of something we devote considerable time and space to, *i.e.*, wire strain gauges to measure force, small displacement, torque and angle. Please study web based treatments of this topic that differ somewhat from the book in detail and emphasis. *E.g.*, we don't do electrical or hydraulic dynamometers to measure torque. Similarly, although LVDT was mentioned we do not do any problems.
- Chapter 9 is followed quite faithfully up to, but not including, radiation devices. These are mentioned but, again, no problems are assigned or done in class. Also nothing beyond p.293 is dealt with.
- Chapter 10 is dealt with up to p.332. The main themes in flow measurement are energy and continuity; potential and kinetic energy due to pressure and velocity. Concentration is on Pitot tube for flow velocity measurement and "obstruction meters" for mass flow in pipes and ducts. Pay attention to units checking and conversion.
- Study the enumeration that follows for more detail.

1. A 6-bit successive approximation ADC, the comparator, a DAC and binary decision. Note "flash convertor", introduced later to avoid successive decision delay. (not important)
2. Binary arithmetic, addition, subtraction, conversion to/from decimal, 2's (1's), 10's (9's) complement. Very important; an easy and convenient source of exam questions. This is the only topic concerning digital systems that was emphasized in winter 2007.
3. The "instrument system", introduction to Thévenin's theorem. This makes for a convenient exam question based on Ohm's Law. Don't forget Kirchoff's loop (voltage) and node (current) closure equations that are especially important in bridge circuits wherein the meter has finite input impedance.
4. RMS voltage, the "direct" and "inverse" problems. Given waveform and period, find V_{rms} or with any feasible given combination of two of these, find the third. (again, a convenient exam question)
5. Single and multiarm strain gage bridges, translation (distance from strain), force (stress from strain and force=stress/unit area), Hooke's law, Young's modulus, Poisson's ratio, shear modulus. Computing out of balance voltage using SR4 300Ω strain gages and a standard 5volt power supply. Given the time we spend on these things, almost a dead certainty.
6. Layout of various transducers to measure force (displacement), pressure, diaphragm with bonded and unbonded strain gages. Analog resistor/slide-wire/voltmeter displacement transducer. Digital 4-bit Gray coded displacement transducer and conversion to binary. Why Gray? To avoid transition ambiguity at bit quantum boundaries. Why binary? To obtain an analytic coding of data which can be used in arithmetic. (know Gray code and why it is used and how it is converted)
7. Analysis of end loaded cantilever as a distance and force sensor and its design.
8. Introduction to first order mechanical system, it response to a step input, the notion of time constant. First order systems are distinct exam question possibility of medium probability.
9. Linear distance -*vs*- rotary angle absolute encoders. Gray to binary again. The biphase incremental encoder as a rotary (angle) transducer. (biphase incremental encoder may give rise to a question like, "Given a transition from state 2 to state 3, did that transition represent a forward or backward displacement increment?" This was not dealt with in winter 2007.

10. Torque, shear, torsion bar. The angle/torque analogy of the cantilever distance/force transducer. Shear modulus, Mohr's circle to show $|\sigma| \equiv |\tau|$. A design problem. "Chain of causality" and "underlying physical principle" UFP. (all connected with multiarm bridges; important)

11. Bimetal thermometers and "bang-bang" (on-off) temperature controllers; the thermostat. (unlikely)

12. GPS and the intersection of three spheres problem. It's been done before; be prepared. Note how a fourth sphere resolves the ambiguity of a double solution. Not covered in winter 2007.

13. Combinatorial (parallel) -*vs*- sequential (serial) logic. An elementary "processor" and its 2-bit "instruction". Multibit arithmetic; multiplication, division and square root. A programmable digital door lock to illustrate shift registers and hardware programmability. For your information; not allotted sufficient time last year or in winter 2007.

14. The serial switch and the "single-shot" (monostable multivibrator or MSMV) for frequency division and multiplication. Again, for your information.

15. Flow measurement. Equations and units. Eight typical devices and type classification. Calculating velocity, mass or volume flow rate and pressure (energy) loss dues to friction of a fluid flowing in a pipe or duct. Consider your Pitot tube lab experiment. It is a multipoint velocity mapping of flow velocity profile. (study this)

16. Ohm's and Kirkhoff's laws revisited. Thévenin's theorem done in detail to get open circuit (actual, ideal) voltage by using a single serial "resistor". This compensates for current drain by the measuring instrument (voltmeter) so one may use this reading to find the actual voltage output.

17. Chapter 3 with its treatment of op-amps, filters and the like, the stuff on dB and octaves will almost certainly provide an exam question.

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MECH 262:- TOPICS-STATISTICS

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August 27, 2007

1. Wheeler and Ganji, Chapter 6, pp.118-162. We exclude "Linear Regression Using data Transformation", pp.163 and beyond.
2. Note that first four pages of Chapter 7, pp.180-183 were included as part of MECH 261-262 because "Experimental Uncertainty Analysis" pertains to measurements. It was done in 2006 but not winter 2007.
3. Chapter 6 topics were treated in the sequence in which they appear in the text.
4. The only topic that is not in the text is the fitting of more than three points in the plane to a circle. This was on the April 2006 final exam. It was not covered in winter 2007.
5. There will be three questions, each designed to be do-able in 20 minutes.
6. Be prepared to do questions on binomial and/or Poisson distribution, normal distribution probability and confidence level, confidence level estimation for small samples, *i.e.*, Student's "t" distribution and confidence level on standard deviation/variance using χ^2 distribution graph/table.
7. Correlation coefficient is included.
8. Elimination of "outliers" is included.

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