EE 5340/7340 Exam II Name:____________________

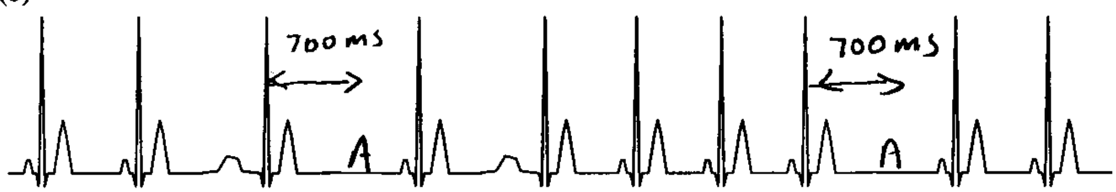
Dec. 10, 1999

1. The ECG signal drawn below was obtained from a patient that is in need of a pacemaker. Indicate on the signal where an artificial stimulus would be applied by a pacemaker assuming the pacemaker was implanted and is of type (a) VAD (b) AVD (c) DDD. Use and "A" symbol to indicate when the atria would have been paced and a "V" symbol to indicate when the ventricles would have been paced. Assume that for the signal shown, two atrial stimuli are required and two ventricular stimuli are required. Explain your reasoning in each case (3 pts each)

(a)

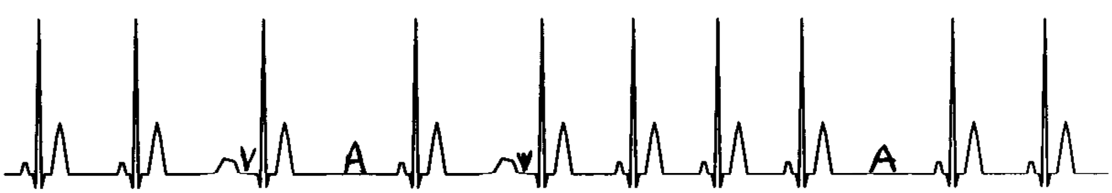
VAD ⇒ V-STIMULATED
A-SENSED
D-TRIGGERING + INHIBITION

(b)



AVD ⇒ A-STIMULATED
V-SENSED
D-T+I

(c)

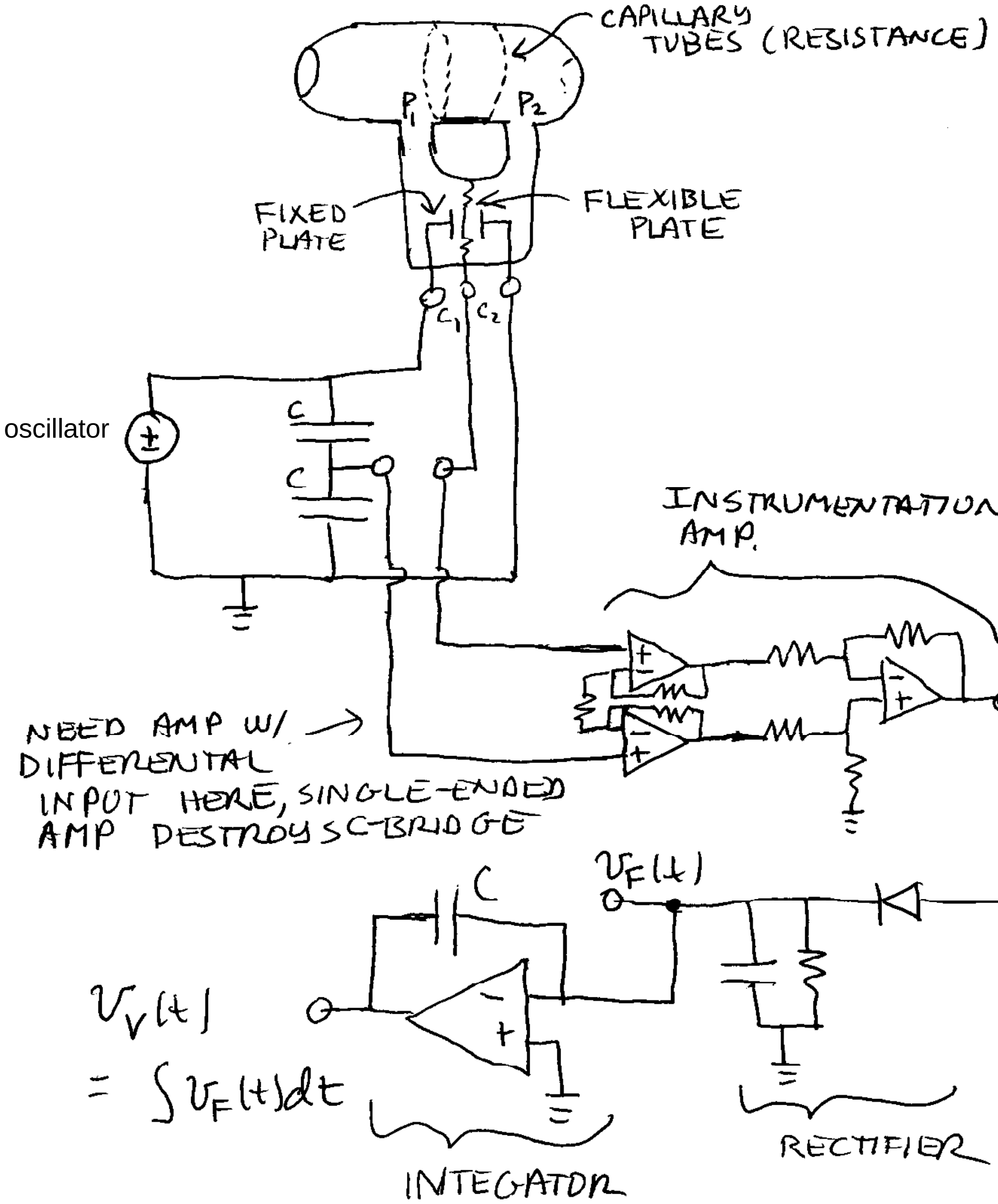


DDD ⇒ D=A+V STIMULATED
D=A+V SENSED
D=T+I

(d) Why is inhibition necessary?

INHIBITION DISCONNECTS SENSING ELECTRODES DURING STIMULUS TO PROHIBIT MISTAKING STIMULUS PULSE FOR NATURAL BEAT

2. Sketch a diagram of a Fleisch pneumotachometer. Include a circuit diagram for generating two voltages: $v_V(t)$ which is proportional to volume and $v_F(t)$, which is proportional to flow. Use any electrical devices you want (op amps, resistors, capacitors, oscillators, etc.) How would the circuit be calibrated to give correct volume and flow readings? (10 pts)

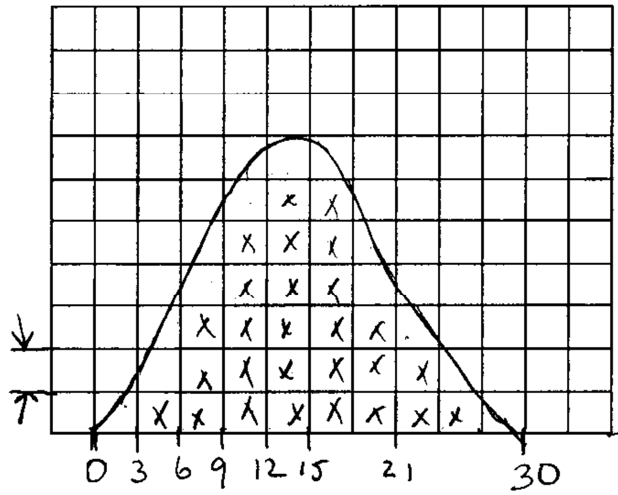


- CALIBRATE WITH A KNOWN FLOW FROM AIR PUMP.

3. (a) A thermodilution measurement gives a cardiac output of 8 liters/min. Assume that V_i = 10 ml, T_i = -30 °K, ρ_i = 1005 kg/m^3, c_i = 4170 J/(kg°K), ρ_b = 1060 kg/m^3, c_b = 3640 J/(kg°K). Sketch a probable temperature curve (ΔT) on the following graph that would produce this reading, be sure to include tick marks on the time and temperature axes. (5 pts):

ΔT_b (°K)

$-\tau = 2.26 \times 10^{-2}$



time (sec)

$\rightarrow t\,(s)$

$A = \int \Delta T_b\, dt$
$= (27+9)$ SQUARES $\times 3 \times \tau$ s-°K
$= 2.44$ °K-s
$\Rightarrow \tau = \frac{2.44}{36 \times 3} = 2.26 \times 10^{-2}$ s

$$F = \frac{V_i \Delta T_i \rho_i c_i}{\rho_b c_b \int \Delta T_b\, dt} = 8 \frac{l}{min} \times \frac{1\ min}{60\ s} \times \frac{10^3\ ml}{1\ l} = 133 \frac{ml}{s}$$

$$= \frac{10\ ml\,(-30\,°K)\,1005 \frac{kg}{m^3}\, 4170 \frac{J}{kg°K}}{A\, 1060\ kg/m^3\ 3640\ J/kg°K} = \frac{-325.8}{A} \frac{°K\text{-}ml}{s} \Rightarrow A = \frac{-325.8}{133} = -2.44\ °K\text{-}s$$

(b) Find the blood velocity corresponding the the diagram on slide 487 if the doppler frequency shift is 100 Hz, $\theta_t = \theta_r = 45°$, and an ultrasound transmission frequency of 2 MHz (5 pts):

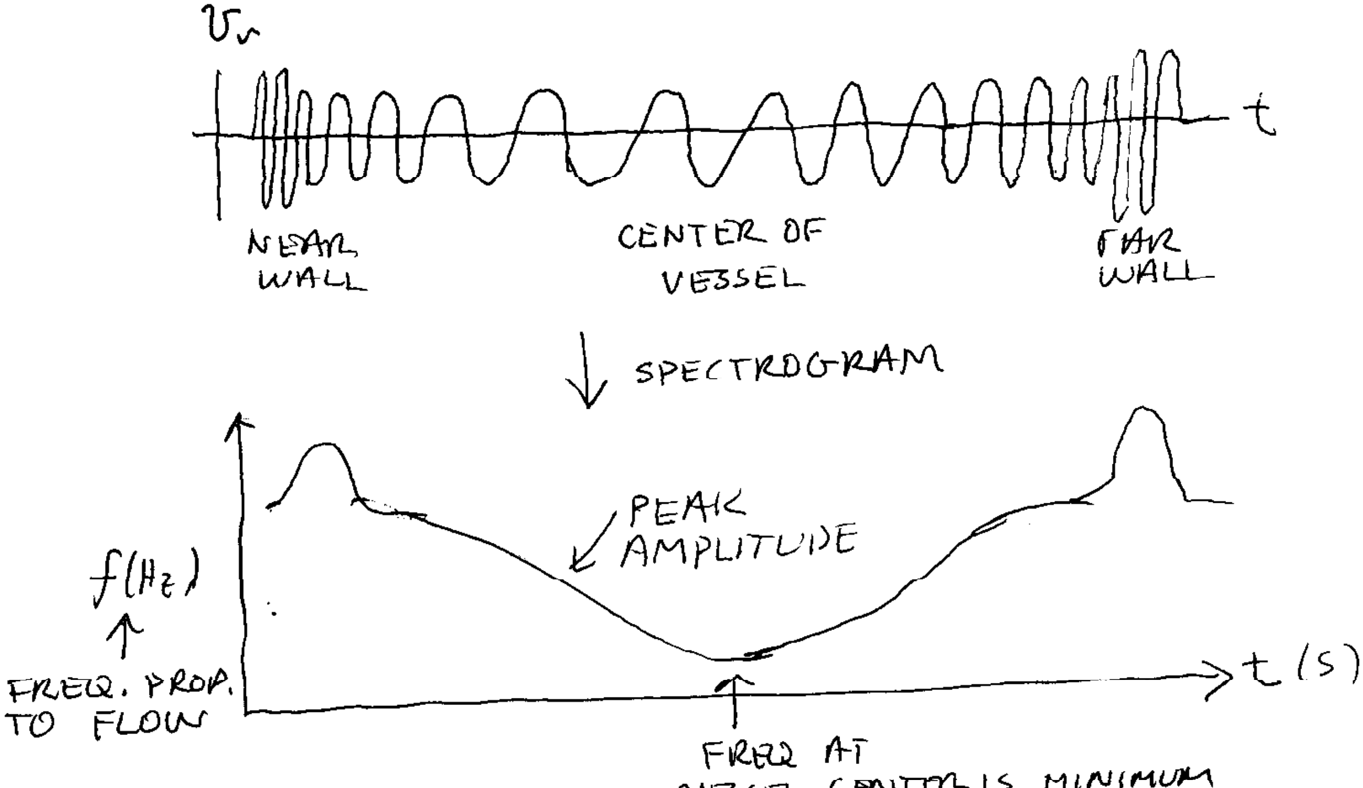
$$f_d \approx -\frac{u}{c}(\cos\theta_t + \cos\theta_r) f_t$$

$$\therefore\ u = -\frac{f_d\, c}{(\cos\theta_t + \cos\theta_r) f_t}$$

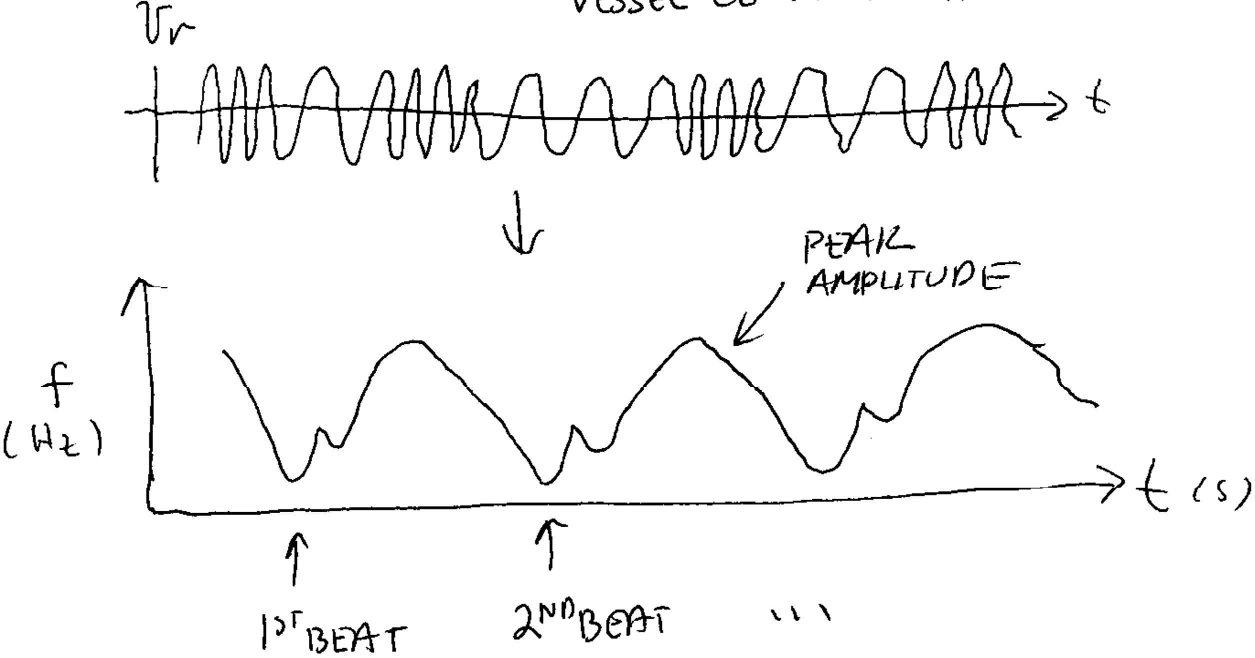
$$= \frac{-100\ s^{-1} \times 1500\ m/s}{\sqrt{2} \times 2 \times 10^6\ s^{-1}} = -5.3 \times 10^{-2}\ m/s$$

4. (a) Describe how the spectrogram can be used to image the blood flow profile in pulsed Doppler flow measurement. (5 pts) (b) How con the spectrogram be used to image blood flow over several heart beats in CW flowmetry? (5 pts)

(a) ASSUME BLOOD MOVING AWAY FROM SENSOR. REFLECTED PULSE:



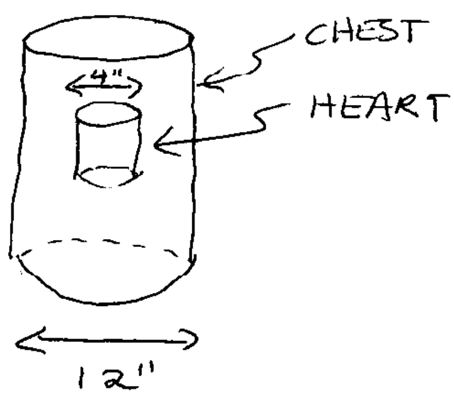
(b)



5. (a) Describe the difference between microshock and macroshock. Give an example of each type of shock. (b) Assume the chest can be modelled as a cylinder of diameter of 12 inches having uniform resistivity. Assume that current is introduced uniformly along the top of the cylinder and exits uniformly along the bottom of the cylinder and that the current density in A/in^2 is constant along any cross section of the cylinder. Assume the heart is also cylindrical in shape and has a diameter of 4 inches. How much current is flowing into the chest if the current passing through the heart is 10 μA?(c) Describe one source of 60 Hz noise in electrophysiology and how it can be eliminated. (3 pts each)

(a) RIGHT OUT OF NOTES

(b)



LET I = TOTAL CURRENT

CURRENT DENSITY $= \rho = \frac{I_{TOT}}{\pi r^2} = \frac{I_{TOT}}{\pi 6^2}$ A/m²

CURRENT THROUGH HEART $= I_H$

$$I_H = 10\,\mu A = \pi 2^2 \rho$$

$$= \pi \cdot 4 \cdot \frac{I_{TOT}}{36\pi}$$

$$\Rightarrow I_{TOT} = 10\,\mu A \times \frac{36}{4} = 90\ \mu A$$

(c) SEE NOTES