

Instructions:

1. Please check to ensure that you have a complete exam booklet. There are 25 numbered problems. Note that **Problem 14 occupies 3 pages, Problems 1, 2, 3, 4, 13, 16 and 17 occupy 2 pages.** Including the cover sheet, you should have **35 pages.** There should be no blank pages in the booklet.
2. The examination is closed book and closed notes. No reference material is allowed at your desk. A calculator is permitted.
3. All wireless devices must be turned off for the entire duration of the exam.
4. You may work a problem directly on the problem statement (if there is room) or on blank sheets of paper available from the exam proctor. Do not write on the back side of any sheet.
5. Your examination code number **MUST APPEAR ON EVERY SHEET.** This includes this cover sheet, the problem statement sheets, and any additional work sheets you turn in. **DO NOT** write your name on any of these sheets. Use the preprinted numbers whenever possible, or **WRITE LEGIBLY!!!**
6. Under the rules of the examination, you must choose 8 problems to be handed in for grading. Each problem to be graded should be separated from the rest of the materials, stapled to the associated worksheets, and placed on the top of the appropriate envelope in the front of the exam room. **DO NOT TURN IN ANY SHEETS FOR THE OTHER 17 PROBLEMS!!**
7. The examination lasts 4 hours, from 9:30 AM to 1:30 PM.
8. When you hand in the exam:
 - (a) Separate the 8 problems to be graded as explained above.
 - (b) Check to see that your Code Number is in **EVERY** sheet you are turning in.
 - (c) On the section at the bottom of this page, **CIRCLE** the problem numbers that you are turning in for grading.
 - (d) Turn in this cover sheet (containing your code number) and the 8 problems to be graded.
 - (e) All other material is to be placed in the discard box at the front of the room. You are not allowed to take any of the exam booklet pages from the room!

1	2	3	4	5	6	7	8	9
10	11	12	13	14	15	16	17	18
19	20	21	22	23	24	25		

Problem 1 (Core: CompE-ECE2030)**Code Number:** _____

You are to design a 4-2 priority encoder module. There are four inputs I_0 , I_1 , I_2 , and I_3 . The output must encode the subscript of the highest priority asserted (logical 1) input. Inputs with lower subscripts have higher priority. Be sure to correctly handle the case when no inputs are asserted.

a. (3 pts) Derive an implicant table (a truth table that may have don't cares in the input variables) to specify the priority encoder. All outputs necessary to implement the above functionality must be specified.

b. (3) Develop minimized logic expressions for the outputs specified in a. You must show your work to receive full credit for the minimization.

Problem 1 (Core: CompE-ECE2030)

Code Number: _____

c. (4) Using a rectangular symbol for the encoder designed above show how to use some number of 4-2 priority encoders to design an 8-3 priority encoder which encodes 8 subscripted inputs ($I_7..I_0$) in 3 bits. As before the output should encode the subscript of the highest priority asserted input, and lower numbered subscripts have higher priority You may use any additional logic gates, multiplexors or decoders that you need.

Problem 2 (Core: CompE-ECE2030) Code Number: _____

- a) Using Boolean algebra, simplify this expression such that it has less than or equal to 5 literals. Put in SOP form.

$$OUT = A\bar{B}\bar{C} + C + D\bar{A}B + D\bar{A}\bar{B}$$

- b) Show the LOGIC schematic for the following Boolean function. Please show the implementation (preferably with mixed logic notation) using NOR gates and INVERTERS only.

$$F = \bar{X}\bar{Y} + \overline{\overline{Z}\overline{W} + A}$$

c)

Problem 2 (Core: CompE-ECE2030)**Code Number:** _____

- d) Represent the following Boolean expression into the below k-map. Give the minimized POS and SOP from the k-map.

$$F = \overline{A}\overline{B}\overline{C}\overline{D} + \overline{A}BC + ABCD + \overline{A}BC\overline{D} + ABD + \overline{A}BCD + A\overline{B}\overline{C}\overline{D}$$

		CD			
		00	01	11	10
AB	00				
	01				
	11				
	10				

Problem 3 (Core: CompE-ECE3055)**Code Number:** _____

The following RISC assembly language program is executed on a 32-bit MIPS processor. Fill in the register values that will be present, after execution of this program. A summary of MIPS instructions is included at the bottom of the page – for anyone unfamiliar with the MIPS instruction set. Prior to execution of the program, memory location 0x01000 contains 0x20313055. *Note:* 0x indicates hexadecimal and all answers must be in hexadecimal, default is decimal in the MIPS assembly language source file. A MIPS memory word or register contains 32-bits. Use XXXXXXXX for an undefined value.

```
lw      $3, 0x01000
        srl      $4, $3, 5
        sub     $2, $3, $4
        xor     $3, $4, $3
        lui    $5, 0x8031
        ori    $5, $5, 78

sub     $6, $4, $3
        bne    $3, $6, LABEL1

ori    $6, $0, 20

LABEL1: sw      $6, 0x01000
```

After execution of the MIPS code sequence above,

R2 = 0x_____ (in hexadecimal)

R3 = 0x_____ (in hexadecimal)

R4 = 0x_____ (in hexadecimal)

R5 = 0x_____ (in hexadecimal)

Memory Location 0x01000 contains: 0x_____ (in hexadecimal)

The MIPS processor contains thirty-two 32-bit registers, \$0 through \$31. \$0 always contains a zero. By default, all arithmetic operations use two's complement arithmetic. Assume no branch delay slot is present.

MIPS Instruction	Meaning
ADD Rd, Rs, Rt	- Rd = Rs + Rt (R – register (\$))
AND Rd, Rs, Rt	- Rd = Rs bitwise logical AND Rt (R – register (\$))
ORI Rd, Rs, <i>Immed</i>	- Rd = Rs bitwise logical OR <i>Immediate</i> value
LUI Rd, <i>Immed</i>	- Rd = 16-bit <i>Immediate</i> value high 16-bits, 0's low 16-bits
BNE Rs, Rt, <i>address</i>	- Branch to <i>address</i> , only if Rs not equal to Rt

Problem 3 (Core: CompE-ECE3055)**Code Number:** _____

LW	Rd, <i>address</i>	-	LOAD - Rd gets contents of memory at <i>address</i>
SRL	Rd, Rs, <i>count</i>	-	Shift right logical (<i>use 0 fill</i>) by <i>count</i> bits
SUB	Rd, Rs, Rt	-	Rd = Rs - Rt
SW	Rd, <i>address</i>	-	STORE - memory at <i>address</i> gets contents of Rd
XOR	Rd, Rs, Rt	-	Rd = Rs bitwise logical XOR Rt

Problem 4 (Core: CompE-ECE3060) Code Number: _____

(10 pts) Consider a NOR4 gate $F = \overline{a+b+c+d}$ with the equal rise and fall time. Assume that the ratio between the width of pFET and nFET is 2:1 for an inverter with the equal rise/fall time.

a) (2 pts) Draw the CMOS transistor-level schematic of NOR4.

b) (3 pts) Draw a stick diagram of NOR4.

Problem 4 (Core: CompE-ECE3060) Code Number: _____ c) (5 pts)

c) Using the RC delay model, compute the delay of NOR4 driving a load of $100C_{inv}$ in term of τ . Assume that the input capacitance of each input is $5C_{inv}$. C_{inv} is the input capacitance of the minimum-sized inverter, and $\tau = R \cdot C_{inv}$. R is the resistance of the minimum-size nFET.

Problem 5 (Core: E&M-ECE3025)

Code Number: _____

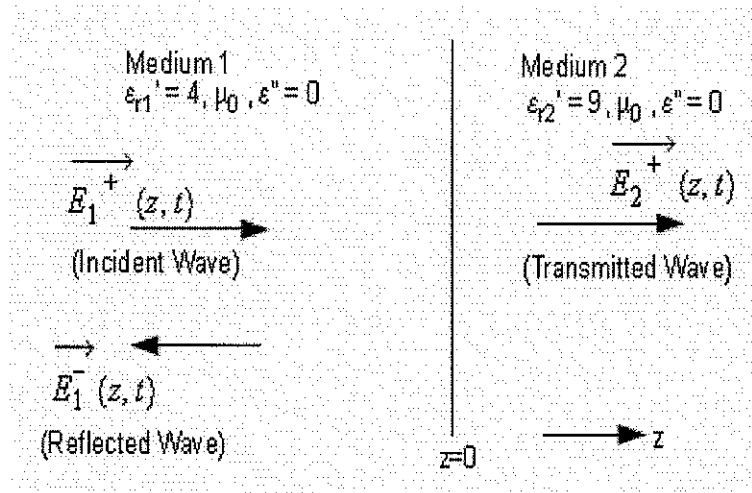
A standard AM broadcast band transmitting station consists of two vertical monopoles above the earth. The two antennas are separated by 50 m and the transmitting frequency is 1500 KHz. The antennas are fed with signals of equal amplitude and a phase difference of 135° . Sketch the electric field pattern at the surface of the earth. Show the location of all maxima and minima and their relative values.

Problem 6 (Core: E&M-ECE3065)**Code Number:** _____

Consider two lossless, non-magnetic, dielectric media as shown in the figure below. The interface between the two media is on the x-y plane at $z=0$. A uniform plane wave traveling in medium 1 is incident normally at the interface. The electric field of the incident wave is given as:

$$\vec{E}^+(z,t) = 10 \cos(\omega t - \pi z) \hat{a}_x \quad \left(\frac{V}{m}\right)$$

This wave generates a reflected wave in medium 1 and a transmitted wave in medium 2, as shown in the figure below. The relative permittivity of medium 1 and 2 are $\epsilon_{r1}=4$ and $\epsilon_{r2}=9$, respectively.

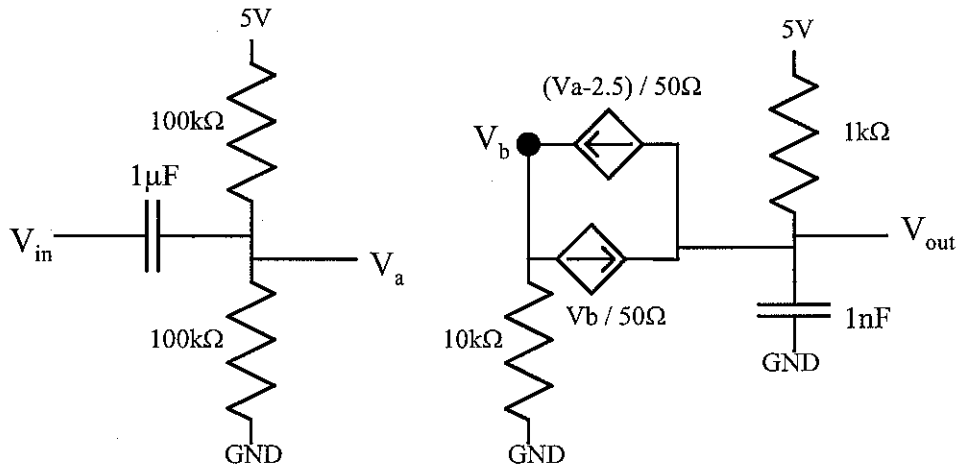


- Calculate the frequency of the wave.
- Calculate the minimum distance from the interface at which the total magnitude of electric field in Medium 1 is a maximum.
- Calculate the standing wave ratio of the wave in medium 1.
- Calculate the electric field of the transmitted wave in medium 2 at a distance of $z=1\text{m}$ from the interface and at time $t=13.33\text{ns}$.
- Calculate the average power density of the transmitted wave in medium 2.

Problem 7 (Core: EDA-ECE2040)

Code Number: _____

Answers must be written on the line to receive any credit.



The following questions relate to the DC operation of this circuit. Assume we apply a dc input (V_{in}) voltage of 3.7V.

DC voltage at V_a = _____ DC voltage at V_b = _____

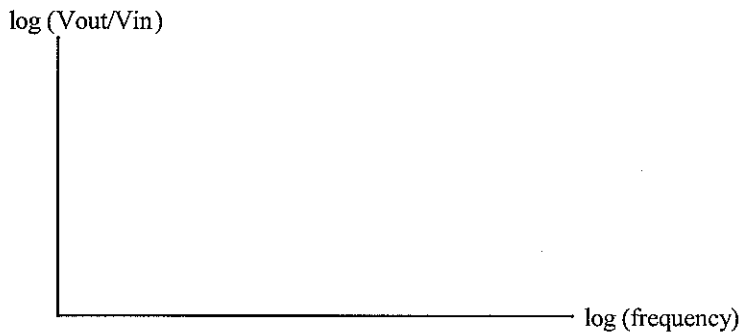
DC voltage at V_{out} = _____

What condition does one use to calculate the dc parameters? _____

The following questions relate to the AC operation of this circuit. Assume we apply in input signal, $V_{in} = (10\text{mV}) \sin \omega t$, where ω is the input frequency of the signal.

What is the gain between V_a and V_b ? _____

Plot the frequency response of the circuit, namely $\log |V_{out}(j\omega) / V_{in}(j\omega)|$ versus $\log(\text{frequency})$. Identify appropriate breakpoints and other key aspects in the graph.



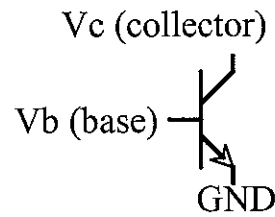
What are the two corner frequencies for this circuit? _____ Hz and _____ Hz

What is the midband gain for this circuit? _____

Problem 8 (Core: EDA-ECE3050)

Code Number: _____

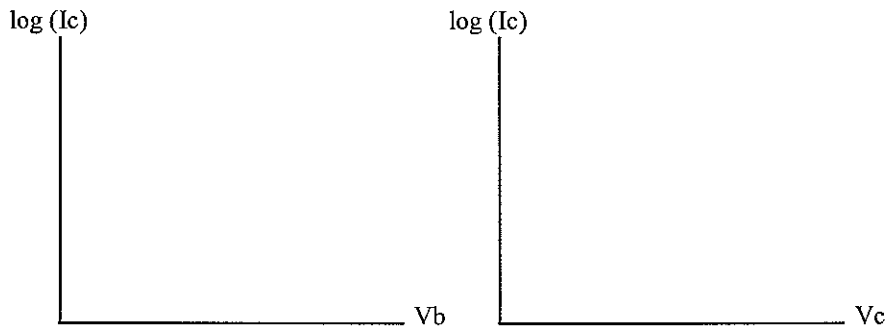
Assume the BJT devices have a "Beta" that is infinite, that $I_s = 1\text{pA}$, and that the collector and emitter dopings are identical (you might identify this device similar to a subthreshold MOSFET with "kappa" =1).



Write the (large-signal) expression for the collector current (I_c) versus V_b and V_c

$I_c =$ _____

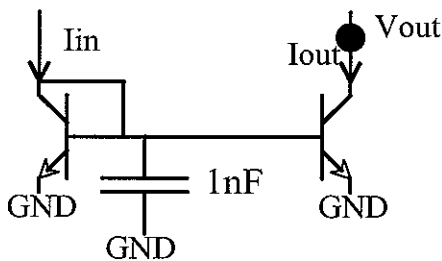
Plot $\log I_c$ versus V_b , and $\log I_c$ versus V_c . Identify key breakpoints on graph.



What is the slope of the curve ($\log I$ versus V_b) at $1\mu\text{A}$? _____

What is the slope of the curve (I versus V_b) at $1\mu\text{A}$? _____

What voltage for V_c defines the boundary between the ohmic and forward active region? _____



Assume the transistors are identical.

What is the gain (I_{out}/I_{in}) for this circuit when $I_{in} = 1\mu\text{A}$? _____

How low can V_{out} decrease and the corresponding transistor act like a voltage-controlled current source? _____

For a small signal input riding on a dc current of $1\mu\text{A}$, what is the low-pass corner frequency of this circuit? _____ Hz

Problem 9 (Core: Power-ECE3070)**Code Number:** _____

An electromechanical actuator with a single coil and an air gap has a λ - i relationship given by,

$$\lambda = \frac{1.2i^{1/2}}{g}$$

where λ is the flux linkages of the coil, i is the current in the coil, and g is the air gap length. Assume that there is a dc current in the coil of 2 A.

If the air gap length is 10 cm ...

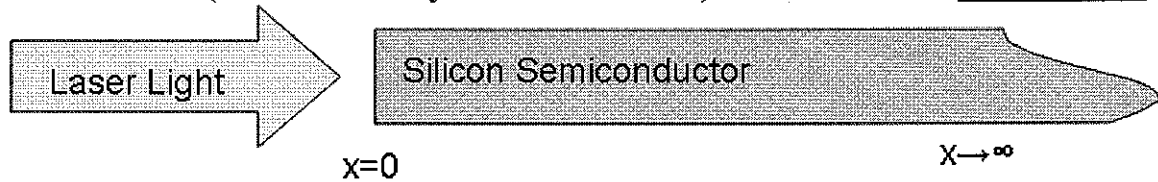
- (a) Determine the energy stored in the magnetic field.
- (b) Determine the force acting on the air gap.

Problem 10 (Core: Power-ECE3070)**Code Number:** _____

The per phase synchronous reactance of a three-phase, Y-connected, 60 Hz, 4-pole, synchronous generator is 10 ohms. When a certain load is connected to the generator terminals, it supplies 2.5 MVA (total three phase) at 60 Hz, at a leading power factor of 0.8 and a terminal voltage of 6.6 kV (L-L), to the load. Neglect armature resistance, magnetic saturation, and all mechanical losses. For the above load condition:

- a) Find the speed of the generator.
- b) Calculate the mechanical torque supplied by the turbine which drives this generator.
- c) Draw the phasor diagram showing \tilde{V}_t , \tilde{E}_{af} , \tilde{I}_a and $jX_s\tilde{I}_a$. Recall that $\tilde{V}_t = \tilde{E}_{af} - jX_s\tilde{I}_a$. Use V_t as the reference phasor. Calculate the magnitude (expressed as a L-N value) of the excitation voltage (or induced voltage) E_{af} .
- d) The load is now removed from the generator terminals and the field current and speed of the generator remain unchanged. Find the new value of the terminal voltage expressed as a Line-to-Neutral (L-N) value.

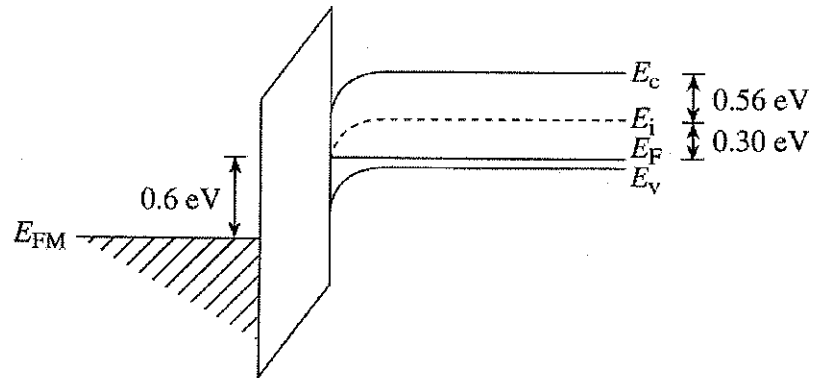
Problem 11 (Core: Microsystems-ECE3040) Code Number: _____



A semi-infinite (with limits at $x=0$ and $x=\infty$) slab of silicon semiconductor (energy bandgap = 1.1 eV, intrinsic concentration = $1 \times 10^{10} \text{ cm}^{-3}$, and donor doped to $6 \times 10^{17} \text{ cm}^{-3}$, minority carrier lifetime = 1×10^{-5} seconds, and minority carrier mobility = $500 \text{ cm}^2/\text{Vsec}$) is illuminated by a high photon energy laser (each photon having 4 eV of energy) such that most all of the light is absorbed in a thin layer near the surface approximated as a two dimensional sheet. If the continuous, time independent light results in a steady state hole concentration at the illuminated surface (i.e. at $x=0$) of $1 \times 10^{12} \text{ cm}^{-3}$, solve the one dimensional minority carrier diffusion equation (showing your work) to result in an equation describing the hole concentration at all positions x .

Problem 12 (Core: Microsystems-ECE3080) Code Number: _____

Shown below is the energy band diagram for an ideal (i.e. having no metal-semiconductor work function difference and no oxide charges) MOS-capacitor operated at $T = 300\text{ K}$ with $V_G \neq 0$. Note that $E_F = E_i$ at the Si-SiO₂ interface.



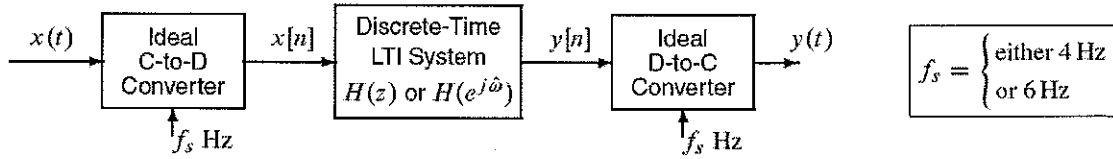
- Do equilibrium conditions prevail **inside the semiconductor**?
- Calculate the Fermi potential ϕ_F .
- Calculate the surface potential ϕ_S .
- Calculate the gate voltage V_G .
- Calculate the oxide thickness x_o .
- Sketch the general shape of the low-frequency C-V characteristic to be expected from the given MOS-C. Place an X on the C-V characteristic at a point that roughly corresponds to the state pictured in the energy band diagram.

You might need: $V_G = \phi_{ms} + \phi_S + \frac{K_S x_o}{K_o} \sqrt{\frac{2qN_A}{K_S \epsilon_0}} \phi_S$, $\epsilon_0 = 8.85 \cdot 10^{-14}\text{ F/cm}$, $K_O = 3.8$,
 $K_S = 11.8$, $q = 1.6 \cdot 10^{-19}\text{ C}$

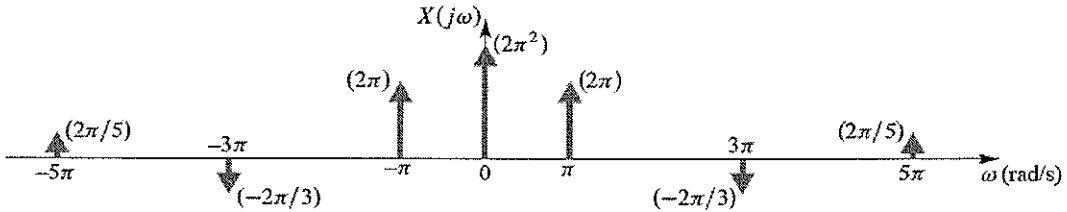
Problem 13 (Core: DSP-ECE2025)

Code Number: _____

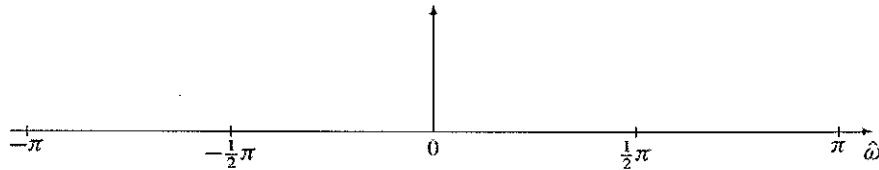
Consider the following system for continuous-time and discrete-time processing of a signal:



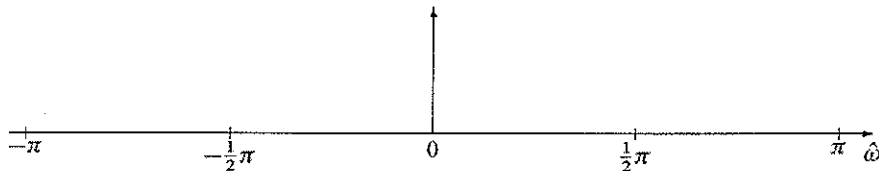
The periodic input, $x(t)$, to the above LTI system is *bandlimited* with a continuous-time Fourier transform $X(j\omega)$ shown below (where the arrows denote impulses).



- (a) There are only two possible sampling rates to be considered in this problem, $f_s = 4$ Hz and $f_s = 6$ Hz. Draw the spectrum of the discrete-time signal $x[n]$ when $f_s = 6$ Hz.



- (b) Draw the spectrum of $x[n]$ when $f_s = 4$ Hz. Use this spectrum and the previous one when answering the matching questions in parts (c), (d), (e), and (f).



Problem 13 (Core: DSP-ECE2025)

Code Number: _____

For the following outputs of the overall system, pick from the lists below the sampling rate of the C-to-D and D-to-C converters, as well as the discrete-time system that could have produced that output when the input $x(t)$ has the Fourier transform given above. [Circle the correct sampling rate and also circle the correct choice for the system. There is only one correct answer for each case.]

- (c) $y(t) = x(t) - \pi$ $f_s = 4\text{ Hz, or } 6\text{ Hz}$ (1) (2) (3) (4) (5) (6) (7) (8)
- (d) $y(t) = 0$ $f_s = 4\text{ Hz, or } 6\text{ Hz}$ (1) (2) (3) (4) (5) (6) (7) (8)
- (e) $y(t) = x(t - \frac{1}{3})$ $f_s = 4\text{ Hz, or } 6\text{ Hz}$ (1) (2) (3) (4) (5) (6) (7) (8)
- (f) $y(t) = -\frac{4}{15} \cos(3\pi t)$ $f_s = 4\text{ Hz, or } 6\text{ Hz}$ (1) (2) (3) (4) (5) (6) (7) (8)

The possible discrete-time systems are described below. *Not all of these will be used.*

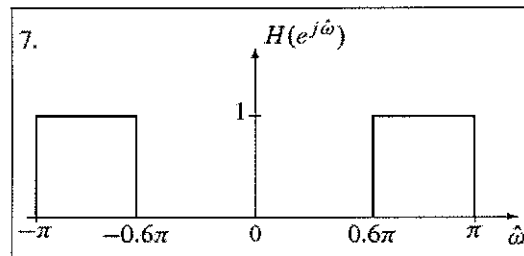
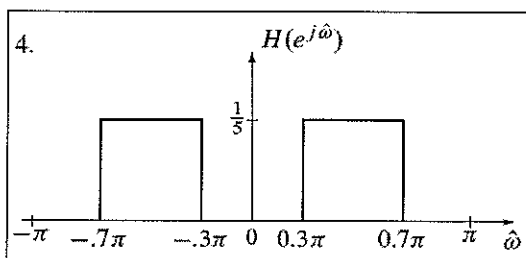
$$1. H(e^{j\hat{\omega}}) = \begin{cases} 0 & |\hat{\omega}| < 0.1\pi \\ 1 & 0.1\pi \leq |\hat{\omega}| \leq \pi \end{cases}$$

$$5. H(e^{j\hat{\omega}}) = \begin{cases} 1 & |\hat{\omega}| \leq 0.2\pi \\ 0 & 0.2\pi < |\hat{\omega}| \leq \pi \end{cases}$$

$$2. H(z) = z^{-2}$$

$$6. H(e^{j\hat{\omega}}) = \begin{cases} e^{-j\hat{\omega}} & |\hat{\omega}| \leq 0.9\pi \\ 0 & 0.9\pi < |\hat{\omega}| \leq \pi \end{cases}$$

$$3. H(z) = z^{-3}$$



8. NONE of the above

Problem 14 (Core: DSP-ECE3075)**Code Number:** _____

Consider a pair of jointly Gaussian random variables X & Y . Below are some key statistics:

$$\begin{aligned}E(X) &= 0 \\E(Y) &= 2 \\E(X^2) &= 9 \\E(Y^2) &= 8 \\E(XY) &= -1\end{aligned}$$

A table of the cumulative distribution function of a zero mean, unit variance Gaussian random variable is attached. Also note the probability density function formula below:

$$\text{If } X \sim N(a, \sigma^2) \text{ then } f_X(x) = \frac{1}{\sqrt{2\pi}\sigma} \exp\left[-\frac{1}{2}(x-a)^2/\sigma^2\right]$$

- (a) Find the marginal densities of X and Y .
- (b) Find the correlation coefficient, ρ , between X and Y .
- (c) Find the probability that $-1 \leq X \leq 1$. Express this in terms of $\Phi(\alpha)$, the cumulative distribution function of a zero mean, unit variance Gaussian random variable. A table is attached.

Problem 14 (Core: DSP-ECE3075)

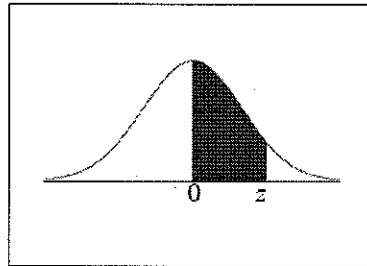
Code Number: _____

(d) We are 99% confident that X will take on an experimental value less than v . Find v .

(e) An average is taken of ten, independent experimental values of X . Find the standard deviation of this average.

(f) Let $W = 3X - 5Y$. Find the pdf of W .

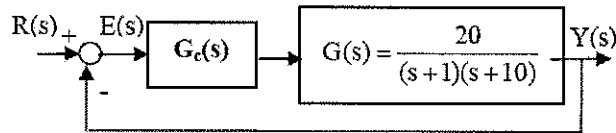
Standard Normal Distribution Table



z	.00	.01	.02	.03	.04	.05	.06	.07	.08	.09
0.0	.0000	.0040	.0080	.0120	.0160	.0199	.0239	.0279	.0319	.0359
0.1	.0398	.0438	.0478	.0517	.0557	.0596	.0636	.0675	.0714	.0753
0.2	.0793	.0832	.0871	.0910	.0948	.0987	.1026	.1064	.1103	.1141
0.3	.1179	.1217	.1255	.1293	.1331	.1368	.1406	.1443	.1480	.1517
0.4	.1554	.1591	.1628	.1664	.1700	.1736	.1772	.1808	.1844	.1879
0.5	.1915	.1950	.1985	.2019	.2054	.2088	.2123	.2157	.2190	.2224
0.6	.2257	.2291	.2324	.2357	.2389	.2422	.2454	.2486	.2517	.2549
0.7	.2580	.2611	.2642	.2673	.2704	.2734	.2764	.2794	.2823	.2852
0.8	.2881	.2910	.2939	.2967	.2995	.3023	.3051	.3078	.3106	.3133
0.9	.3159	.3186	.3212	.3238	.3264	.3289	.3315	.3340	.3365	.3389
1.0	.3413	.3438	.3461	.3485	.3508	.3531	.3554	.3577	.3599	.3621
1.1	.3643	.3665	.3686	.3708	.3729	.3749	.3770	.3790	.3810	.3830
1.2	.3849	.3869	.3888	.3907	.3925	.3944	.3962	.3980	.3997	.4015
1.3	.4032	.4049	.4066	.4082	.4099	.4115	.4131	.4147	.4162	.4177
1.4	.4192	.4207	.4222	.4236	.4251	.4265	.4279	.4292	.4306	.4319
1.5	.4332	.4345	.4357	.4370	.4382	.4394	.4406	.4418	.4429	.4441
1.6	.4452	.4463	.4474	.4484	.4495	.4505	.4515	.4525	.4535	.4545
1.7	.4554	.4564	.4573	.4582	.4591	.4599	.4608	.4616	.4625	.4633
1.8	.4641	.4649	.4656	.4664	.4671	.4678	.4686	.4693	.4699	.4706
1.9	.4713	.4719	.4726	.4732	.4738	.4744	.4750	.4756	.4761	.4767
2.0	.4772	.4778	.4783	.4788	.4793	.4798	.4803	.4808	.4812	.4817
2.1	.4821	.4826	.4830	.4834	.4838	.4842	.4846	.4850	.4854	.4857
2.2	.4861	.4864	.4868	.4871	.4875	.4878	.4881	.4884	.4887	.4890
2.3	.4893	.4896	.4898	.4901	.4904	.4906	.4909	.4911	.4913	.4916
2.4	.4918	.4920	.4922	.4925	.4927	.4929	.4931	.4932	.4934	.4936
2.5	.4938	.4940	.4941	.4943	.4945	.4946	.4948	.4949	.4951	.4952
2.6	.4953	.4955	.4956	.4957	.4959	.4960	.4961	.4962	.4963	.4964
2.7	.4965	.4966	.4967	.4968	.4969	.4970	.4971	.4972	.4973	.4974
2.8	.4974	.4975	.4976	.4977	.4977	.4978	.4979	.4979	.4980	.4981
2.9	.4981	.4982	.4982	.4983	.4984	.4984	.4985	.4985	.4986	.4986
3.0	.4987	.4987	.4987	.4988	.4988	.4989	.4989	.4989	.4990	.4990
3.1	.4990	.4991	.4991	.4991	.4992	.4992	.4992	.4992	.4993	.4993
3.2	.4993	.4993	.4994	.4994	.4994	.4994	.4994	.4995	.4995	.4995
3.3	.4995	.4995	.4995	.4996	.4996	.4996	.4996	.4996	.4996	.4997
3.4	.4997	.4997	.4997	.4997	.4997	.4997	.4997	.4997	.4997	.4998
3.5	.4998	.4998	.4998	.4998	.4998	.4998	.4998	.4998	.4998	.4998

Problem 15 (Core: S&C-ECE3085)**Code Number:** _____

Consider a unity feedback system in the figure.



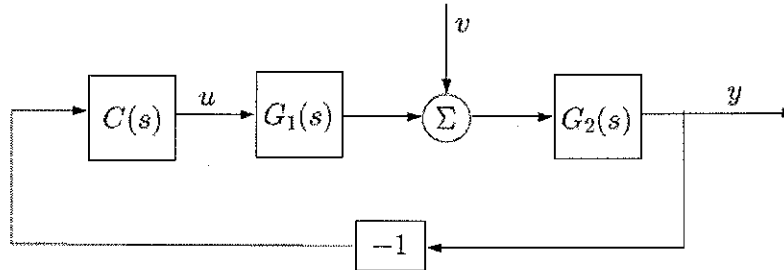
where $G_c(s)$ represents the compensator. The specifications on the closed loop system are to have zero steady-state error for a set point command and no more than 30% steady-state error for sinusoidal inputs up to 10 Hz, where a set point command can be considered as a step input.

- Sketch the frequency response of the closed loop system that satisfies these conditions. Use linear scales.
- Sketch the Bode plot of the open loop system without the compensator.
- Select a simple compensator that will satisfy these conditions.

Problem 16 (Core: S&C-ECE3085)

Code Number: _____

Consider the system given below, where u is the control signal, y is the output, v is a disturbance signal, $G_1(s)$ and $G_2(s)$ are transfer functions, and $C(s)$ is the controller.



a

Find $G(s)$ such that

$$Y(s) = G(s)V(s),$$

where $Y(s)$ and $V(s)$ are the Laplace transforms of y and v respectively.

b

Let

$$G_1(s) = \frac{2}{2+s}, \quad G_2(s) = \frac{4}{s+1}.$$

We want to design the controller $C(s)$ such that the effect of the disturbance v is suppressed. As candidate controllers, consider the following four candidates

$$C_1(s) = 1$$

$$C_2(s) = 4$$

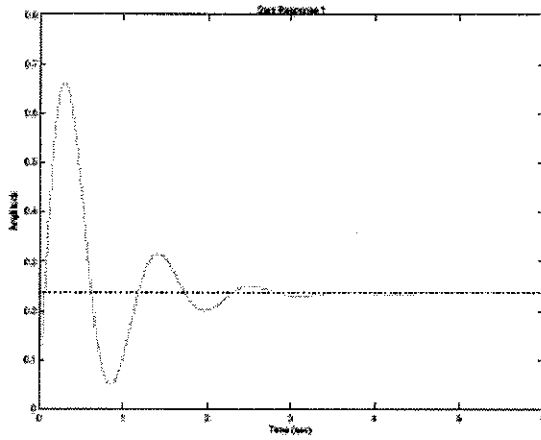
$$C_3(s) = 4 + \frac{1}{s}$$

$$C_4(s) = 1 + \frac{4}{s}$$

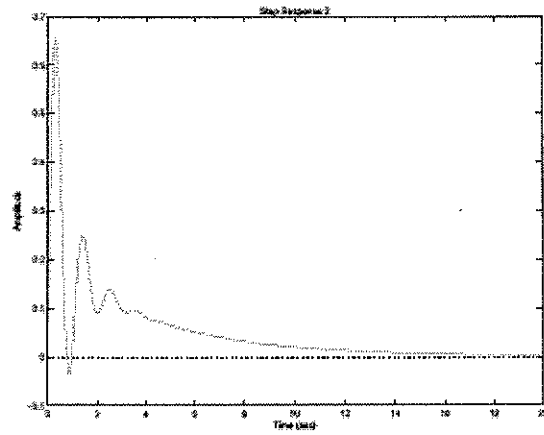
Associate each of these controllers with their corresponding step responses on the next page, under the assumption that the disturbance v is a unit step. (Note: For credit, you must motivate your answer carefully.)

Problem 16 (Core: S&C-ECE3085)

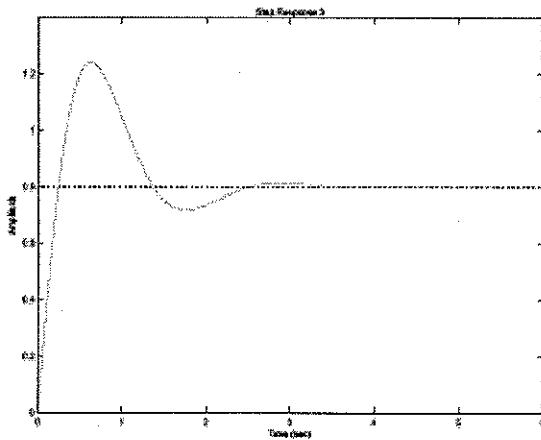
Code Number: _____



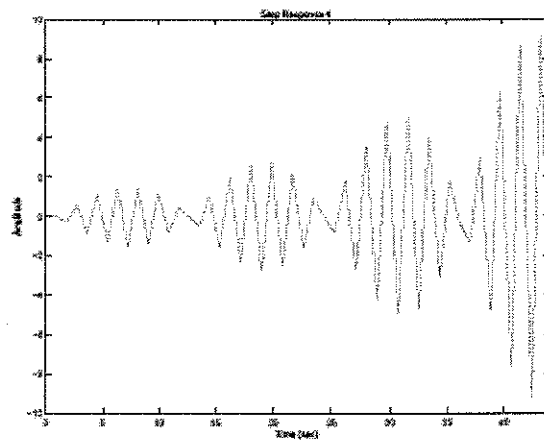
(a) Step Response 1



(b) Step Response 2



(c) Step Response 3



(d) Step Response 4

Problem 17 (Specialized: Comp Science-CS3210) Code Number: _____

d) With the preceding memory system we have four processes operating in a time shared manner and requesting physical memory in units of 64 pages. The current allocation in Mbytes and the maximum amount that can be requested by each process is shown in the table below. Deadlock occurs when processes block indefinitely waiting for sufficient memory to become available to complete execution.

Process	Allocated	Maximum
A	192	512
B	320	384
C	128	192
D	128	384

Define an algorithm for memory allocation that will avoid deadlock while having processes continue executing in a time-shared manner, if the sequence of memory requests permits. Using your algorithm, if C makes a request for 64 Mbytes can it be allocated?

Problem 18 (Specialized: Software Sys- ECE3035) Code Number: _____

Using C-like pseudo-code, write a routine `insert(x, head)` that inserts an integer into a singly-linked list in sorted order (from least to greatest), where `head` is a pointer to the first item on the list (or `NULL` if the list is empty). Make sure to include code to allocate memory for a new item when inserting. Assume that the list contains no duplicate values, i.e. if `x` is already in the list, then the insert routine should not insert anything.

Problem 19 (Specialized: Telecom-ECE3076) Code Number: _____

What four items of information are needed by a host before it can operate normally on the network:

1. _____
2. _____
3. _____
4. _____

If these are not configured manually, what protocol can be used to get them over the network?

5. _____

Before sending an IP datagram, what protocol is used to find the right Ethernet address?

6. _____

What Ethernet address is used for a host not on the local network?

7. _____

If a host knows its own IP address, what does it need to calculate its Network IP and Broadcast IP?

8. _____

How does (9) CIDR and (10) NAT lead to much more efficient use of the available IP address space?

9. _____

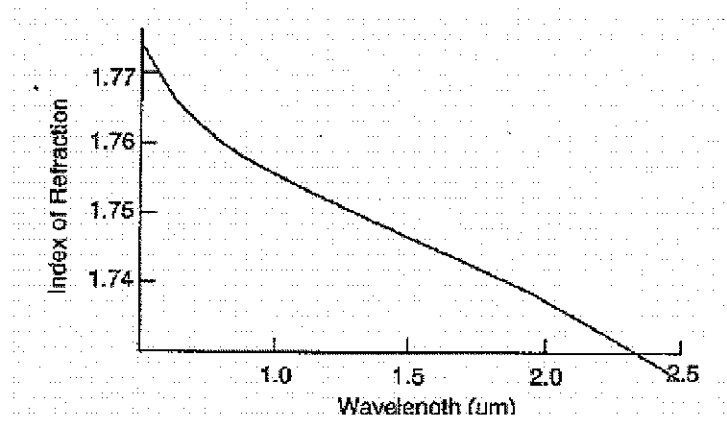
10. _____

Problem 20 (Specialized: Optics-ECE4500) Code Number: _____

Waves

For a wave with free space wavelength 1500nm and propagating in a material with index of refraction as shown

- a) Calculate the wave parameters v , λ , and k of a wave propagating in the medium
- b) Determine the phase and group velocities at 1550nm
- c) Sketch the group velocity vs wavelength over the range of data shown



Problem 21 (Specialized: Optics-ECE4501) Code Number: _____

Longitudinal Modes of Quantum Well Laser

A heterostructure semiconductor laser is fabricated by molecular beam epitaxial growth of the quaternary alloy semiconductor $In_{1-x}Ga_xAs_yP_{1-y}$ in layers of alternating compositions. The laser emits with a gain-bandwidth product of 6 nm centered on the telecommunications wavelength of 1550 nm . The laser cavity is $250\text{ }\mu\text{m}$ in length and has an average refractive index of 3.2771 .

Calculate, showing all work, the longitudinal mode space for this laser. Express your answer in GHz accurately to six significant figures. Calculate, showing all work, all of the discrete frequencies allowed by the laser cavity. Express your answers in THz accurately to five significant figures. Calculate, showing all work, the corresponding discrete wavelengths. Express your answers in nm accurately to five significant figures. Put your final answers in the spaces provided.

Longitudinal Mode Spacing = _____ GHz

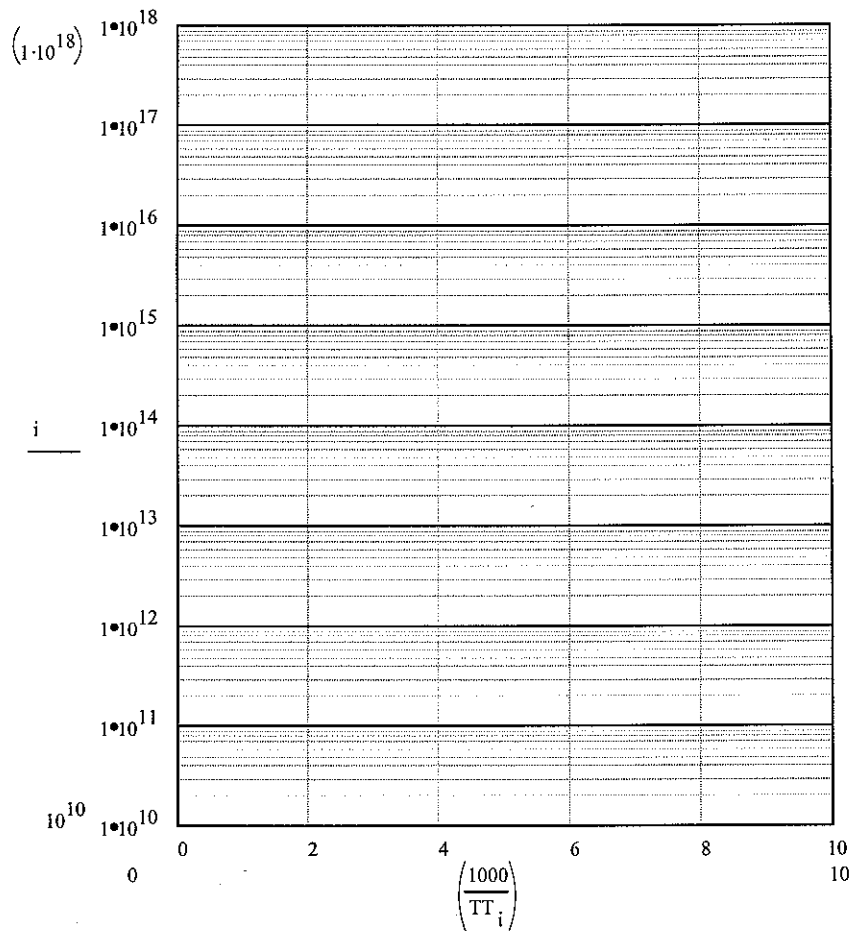
Allowed Discrete Frequencies
(THz)

Corresponding Allowed Discrete Wavelengths
(nm)

Problem 22 (Specialized: Microsystems-ECE4451 Code Number:

Carrier density statistics

- Accurately plot the carrier density vs. inverse temperature for a GaAs ($N_c=4.7 \times 10^{17} \text{ cm}^{-3}$, $N_v=9 \times 10^{18} \text{ cm}^{-3}$) sample with a donor concentration of 10^{15} cm^{-3} and activation energy of 10 meV.
- Identify the three primary regions of carrier density and explain the various regions of behavior.



Problem 23 (Specialized: Bio Eng-ECE4781) Code Number: _____

A.(2 pts) Why do Action Potentials normally travel along a human axon in only one direction?

B.(3 pts) What would happen to an Action Potential if the extracellular concentration of Potassium becomes 20% higher than normal?

C.(2 pts) What would happen to the resting potential of the above neuron if the temperature is increased by a factor of 2 times the normal temperature?

D.(3 pts) How is the Nerve Conduction Velocity measured for diagnoses of Carpal Tunnel Syndrome?

Problem 24 (Specialized: Bio Eng-ECE4781) Code Number: _____

The intracellular and extracellular concentrations for K⁺, Na⁺ and Cl⁻ in the squid axon at rest are given in the table below at T=17°C.

Ion	Intracellular (mM)	Extracellular (mM)	Conductances mS/cm ²	Nernst Potential mV
K ⁺	397	30	0.415	-64.54
Na ⁺	50	437	0.10	54.18
Cl ⁻	40	556	0.582	-65.77

- I. Draw the parallel conductance model.
- II. Determine a resting potential V_{rest} for T=17°C.
- III. Calculate and label the direction for each ion current density.
- IV. During the upswing of an action potential describe the change in Na⁺ conductance from that of the resting state.

Problem 25 (Specialized: Bio Eng-ECE4782) Code Number: _____

A.(4 points) Draw a box diagram of a model showing the large muscle groups (e.g. back muscles, arm muscles, etc) and sensory modalities (e.g. tactile cells on fingers, muscle spindle cells in back, etc) required for a healthy adult to lean over from a chair to tie a shoe.

B.(3 points) Assume that all of the boxes in your model are linear and time invariant. Suggest experiments that would allow you to define the input-output characteristics of each box.

C.(3 points) Explain how you would “cut” some of the feedback loops when characterizing your model.