Be sure to put your ID number on each sheet that has material to be graded. Do not put your name on any sheet.

There are 13 equally weighted problems. You are to SELECT ANY EIGHT of these to answer. You must make it very clear which eight that you choose. (If it is not clear, then the first eight problems that you attempt will be graded.) Indicate your selections in two ways:

1. Circle below which eight problems that you want graded.
2. If you write anything other than your ID number on the page of a question that you do not graded, the cross out that page with a large X from corner to corner.

Circle the eight questions that you want graded:

1
2
3
4
5
6
7
8
9
10
11
12
13

Do all work on the paper supplied to you. Do not write on the back of any page.
Using D flip-flops, design a finite state machine, which implements a modulo-6 synchronous counter. The counter only counts when its enable input $x$ is equal to ‘1’ otherwise the counter is idle.
Problem 2-1

In this DC circuit, $R_L$ is connected as the load.
(a) Find the value of $R_L$ that will cause the load to draw maximum power.
(b) Find the value of that maximum power.
Problem 3-1

3. A unity-gain feedback system (illustrated below) has a forward-path transfer function

\[ H_1(s) = \frac{s + 3}{s^2 + 5s + 4} \]

\[ X(s) \rightarrow \oplus \rightarrow \frac{E(s)}{H_1(s)} \rightarrow Y(s) \]

The overall transfer function of the feedback system is \( H(s) = \frac{Y(s)}{X(s)} \).

(a) If the excitation \( x(t) \) is a unit step, what is the final value of \( y(t) \) (\( \lim_{t \to \infty} y(t) \))?

(b) If \( H_1(s) \) is changed to \( H_2(s) = \frac{s + 3}{s(s^2 + 5s + 4)} \), what is the new final value of \( y(t) \) (\( \lim_{t \to \infty} y(t) \))?
Problem 4-1

Solve the equation

\[ \frac{dy^2}{dx^2} + 2 \frac{dy}{dx} - 3y = 6 \]
Problem 5-1

Given the following program:

```cpp
#include <iostream>
using namespace std;

double eppe (int n, double * c, double x) {
    double r = x;
    while (n--) r = x * (r + *c++);
    return r;
}

int main (void) {
    double a[] = {3.0, 1.0};
    cout << eppe(2,a,2.0) << endl;
    return 0;
}
```

(a) What number is printed?

(b) In the call to `eppe()` from `main()`, what function of `x` (the third argument to `eppe()`) is evaluated?
Paging memory allocation algorithms divide computer memory into small partitions, and allocate memory using a page as the smallest building block.

(a) What are the advantages and disadvantages of paging allocation?

(b) Considering the following paging memory system: there are 4 page table entries, with values 0xC, 0x2, 0x8, 0x5 for entry 0, 1, 2, 3 respectively. The physical memory is 128 bytes, with 8 bytes each frame.

(b.1) How large, in number of bits, of physical address space?
(b.2) How large, in number of bits, of virtual address space?
(b.3) What is the physical address corresponding to virtual address 0x1D? Briefly explain why (result can be either hex or decimal).
(b.4) What is the physical address corresponding to virtual address 0x3? Briefly explain why (result can be either hex or decimal).
Problem 7-1

Assume you are given two arrays of numbers A[] and B[], each of size n, and a number x. You are to describe an efficient algorithm for finding whether there exists a pair of elements, one from A[] and one from B[], that add up to x. Compute and justify the running time of your algorithm using O notation. Your algorithm should be as efficient as possible.
Define Direct Memory Access (DMA). Under what conditions is it most useful?

Explain the concepts of race condition, mutual exclusion, and critical section, and make connections where possible.
Problem 9-1

In the downtown section of a certain city, two sets of one-way streets intersect. At each intersection the number of automobiles entering must be the same as the number leaving. From the four intersections, we obtain the following linear equations:

\[
\begin{align*}
    x_1 + 450 &= x_2 + 610 \\
    x_2 + 520 &= x_3 + 480 \\
    x_3 + 390 &= x_4 + 600 \\
    x_4 + 640 &= x_1 + 310
\end{align*}
\]

(a) Represent the system of linear equations in a matrix equation of the form \( Ax = b \) where \( x = [x_1 \quad x_2 \quad x_3]^T \).

(b) Find a reduced row echelon form of the augmented matrix \([ A \mid b ]\).

(c) Is the system of equations consistent? Justify your answer.

(d) Solve the equation.
1. Consider the $n$-channel JFET circuit shown below. Determine the value of $R_S$ needed to set $I_D$ to $200\mu A$. Assume that $V_P = -1V$ and $I_{DSS} = 2mA$. You may neglect channel-length modulation.

$$R_S = \_\_\_\_\_\_\_\_\_$$
3. A self-excited DC motor is shown as below. $R_a = 0.1 \, \Omega$ and $R_{fw} = 150 \, \Omega$. When the machine is driven at 1200 rpm, we have $V_f = 250 \, V$ and $I_a = 100 \, A$. Also, the data for the magnetization curve at 1200 rpm is given as

<table>
<thead>
<tr>
<th>$I_f$ (A)</th>
<th>...</th>
<th>1.10</th>
<th>1.20</th>
<th>1.35</th>
<th>1.40</th>
<th>1.65</th>
</tr>
</thead>
<tbody>
<tr>
<td>$E_a$ (V)</td>
<td>...</td>
<td>230</td>
<td>240</td>
<td>250</td>
<td>260</td>
<td>270</td>
</tr>
</tbody>
</table>

Determine:
1) The back emf, i.e., $E_a$.
2) The developed torque.
3) The current in the field circuit. Neglect the armature reaction.
4) The value of $R_{fw}$.
1) In a laboratory experiment on a 50 ohms line, the transmission line is unknown load impedance, it was found that the standing wave ratio is 2, the successive voltage minimum are 25 cm apart, and the first minimum occurs at 5 cm from the load, find
a) the load impedance
b) the reflection coefficient
c) use a single stub matching network to match the load to the source,
d) if connected to a source with 50 ohm internal impedance and 1V output voltage, determine the power delivered to the load, and the load current.
A synchronous detector receives the following bandpass signal that has a multipath component: $$v(t) = x_c(t) + \beta x_c(t - t_d)$$. The multipath component has significantly less amplitude than the correct signal. The original bandpass signal operates on carrier frequency of $$f_c$$ and is DSB modulated with message $$x(t)$$.

a. Write the complete expression for $$v(t)$$. 

b. Assuming that $$x(t - t_d) \cong x(t)$$ express the complete expression for $$v(t)$$ in quadrature-carrier form. Hint: use your trig identities. Be sure to clearly express the expressions for $$v_i(t)$$ and $$v_q(t)$$. 

c. What is the expression for the detector’s output? 

d. In general, what type of detector would you use for weak signal AM reception? 

e. Does suppressed carrier double sideband (SCDSB) have any signal-to-noise ratio advantage over suppressed carrier single sideband (SCSSB), and if so, how much?