Name: _____

Problem	Points	Score
1a	10	
1b	10	
2	10	
3a	10	
3b	10	
3c	10	
4a	10	
4b	10	
4c	10	
4d	10	
Total	**100**	

Notes:

1. The exam is closed book / closed notes. You are allowed a copy sheet — only **one** side of **one** standard US-size (8.5” x 11”) sheet of paper — on which you can write relevant information such as equations. You are allowed to bring copy sheets from previous exams.

2. Please show **all** work. Incorrect answers with no supporting explanations or work will be given no partial credit.

3. If I cannot read or follow your solution, it is wrong; and no partial credit will be given — **PLEASE BE NEAT**!

4. Please indicate clearly your answer to every problem.

5. There is sufficient space after each problem to write your solution. In case you need extra paper please see the instructor.

6. Show complete work and detailed steps for proper credit.

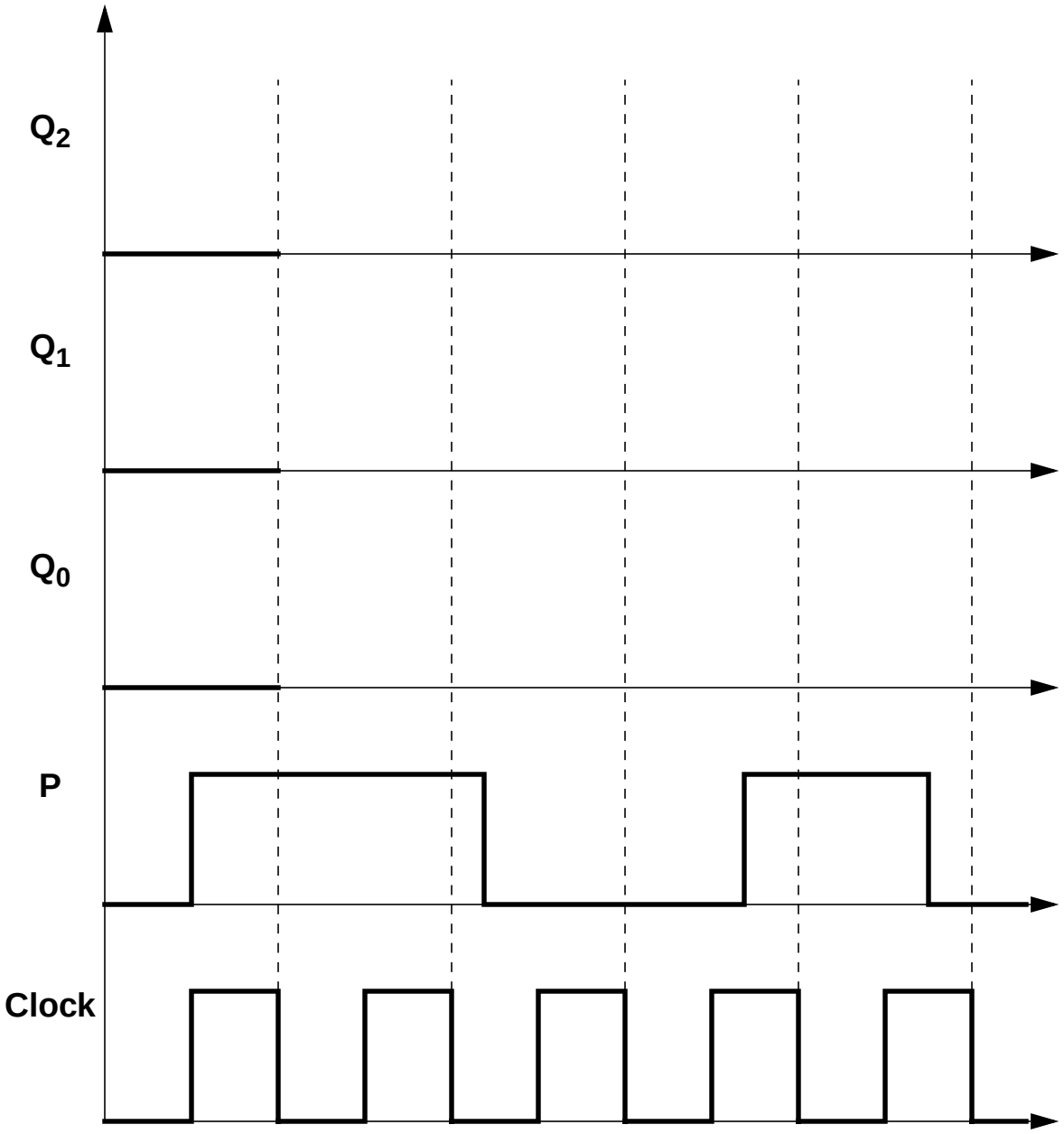
Problem No. 1:

A synchronous sequential digital circuit with three negative edge-triggered D flip-flops has an external input P. The circuit is designed as follows —

$$D_0 = P\overline{Q_2} + Q_1$$
$$D_1 = P$$
$$D_2 = Q_0 + Q_1$$

a) Draw the circuit diagram.

b) Complete the following timing diagram.



Problem No. 2:

A sequential digital circuit counts successive even or odd numbers between 0 and 6, inclusive. If the control input P is 0, the circuit goes through the even numbers starting from 0. If P is 1, the circuit enumerates the odd numbers starting from 1. If the maximum even (odd) value is reached in either case, the circuit restarts from the smallest even (odd) number.

How many flip-flops are required to implement this circuit? Draw a state transition diagram to illustrate the working of this circuit.

Problem No. 3:

An instrumentation amplifier is designed with the following parameters —

$$V_{a,\,dif} = 0.6mV \qquad R_1 = 10k\Omega \qquad R = 1k\Omega$$
$$V_{b,\,dif} = 0.4mV \qquad R_2 = 10k\Omega$$
$$V_{com} = 0.5mV \qquad R_F = 5k\Omega \qquad \Delta R = 5\%$$

a) Find the differential mode output voltage $V_{out,dif}$.

b) Find the common mode output voltage $V_{out,com}$.

c) Find the common mode rejection ratio in dB based on your answers to parts **a)** and **b)**.

Problem No. 4:

Design a 3-bit digital-to-analog converter (DAC) with R_0 = 12kΩ, and an analog voltage range 0-15V using a summing amplifier design. Assume that a 1 bit corresponds to 5V, and a 0 bit corresponds to 0V.

a) Find the voltage increment size δV.

b) Find the value of R_F necessary to build this DAC and draw a circuit diagram.

c) Find the analog output for the binary digital value 110 using the DAC designed in parts **a)** and **b)**.

d) What is the minimum number of bits required to digitize an analog signal with a resolution of 8%? What resolution can one get by using 5 bits?