MiniMathcad Exercise #2 — 150 points
Waste Water Treatment Facility (revisited) — Due: 08 May '98

Continued Assistance: Since you performed so well for the town of East Rutherford, NJ in the design of their Waste Water Treatment Facility, the town has asked you for more assistance in solving two other problems involved with the design of the facility.

1. The town has decided to design the facility with two microbe tanks, operating one microbe tank full time and the secondary tank for half of each day. See the sketch A below. A solid gate will be placed across the entrance to the secondary tank and opened at specific times of the day to allow flow into the secondary tank. The contractors have told you that the gate design calls for a spring latch system that will catch the swinging gate and hold it in the open position. See sketch B on page 2. The contractors have provided you with the following data on the gate and spring design.

a. The gate has a mass of _____ kg.

b. The spring in the spring latch system has a spring constant of _____ N/meter.

c. The system has a shock absorber built into it that, when moved at a velocity of _____m/sec damps the motion of the gate with a resistance of _____ Newtons

d. The gate will contact the spring latch system with a force that is modeled by the equation

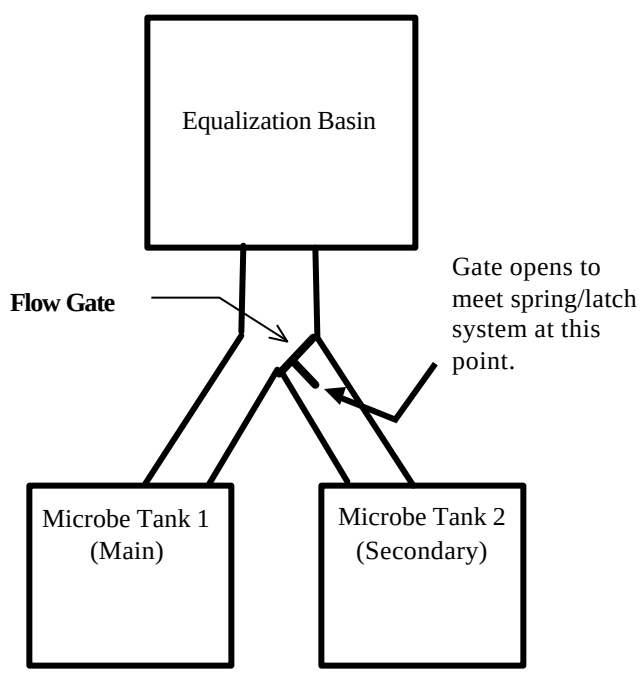
$$f(t) = 3 \cdot e^{-3t}$$

where $f(t)$ is in Newtons and t is the time in seconds after the gate makes first contact with the spring latch system.

e. The gate will be moving at _____ m/sec when it impacts the spring latch system.

The spring latch system is designed such that as soon as the gate makes contact with the spring and the shock absorber, the gate immediately attaches to them. The designers are concerned about the behavior of this spring system and want you to model it so as to determine the long-term behavior of the system.

Determine the 2nd order differential equation that models the motion of this spring latch system. Use Mathcad to determine the particular solution to the model and graph this solution in order to determine the long-term behavior of this system. Discuss the long-term behavior of the system and classify the damping that occurs in the system.



Sketch A

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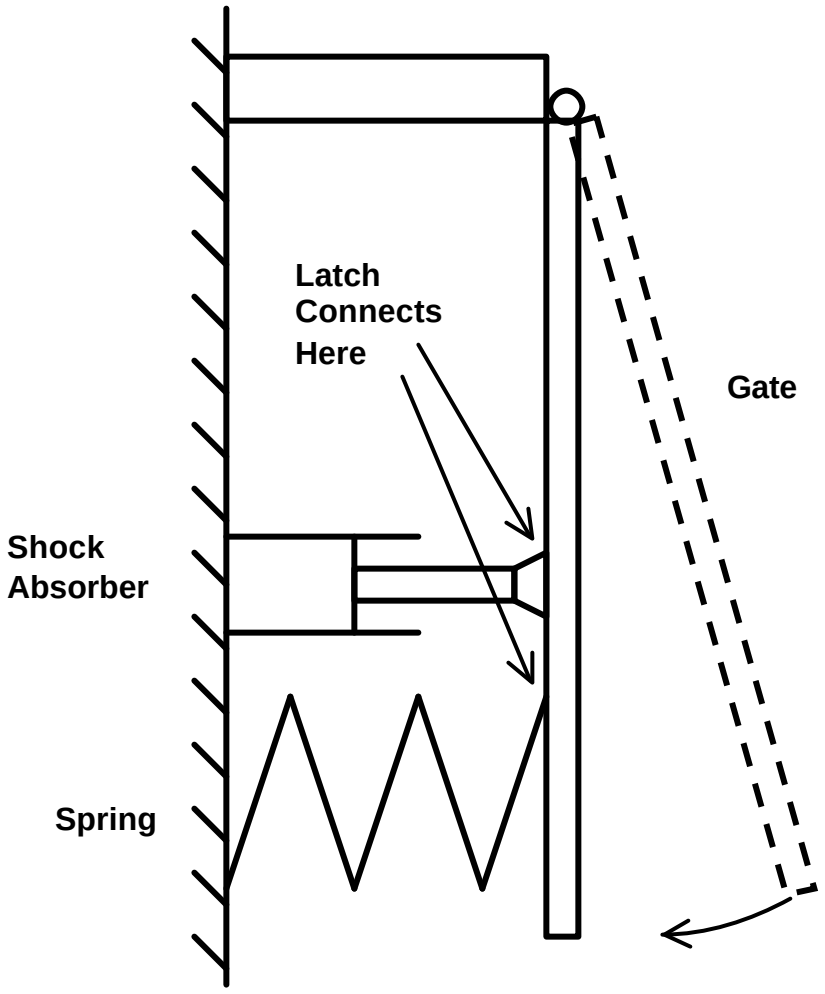
View Looking Down From Above



Sketch B

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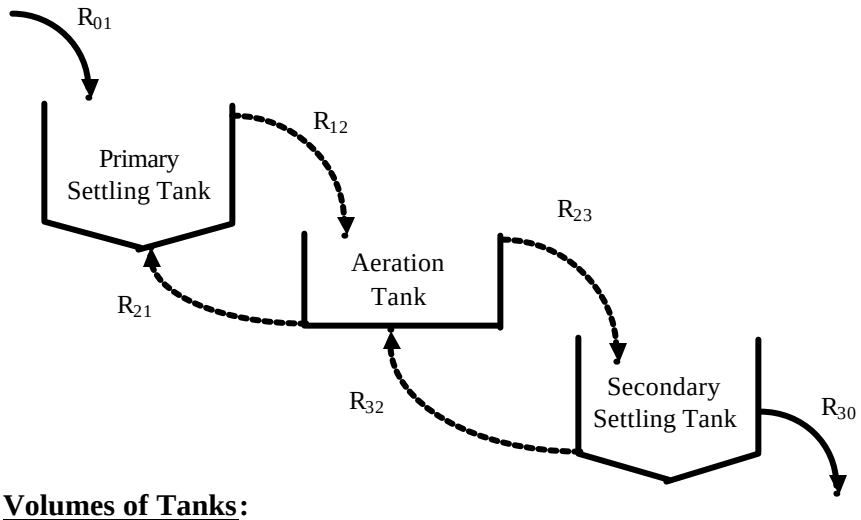
2. The City Engineer has also asked you to assist in determining how to shut down the current treatment facility. The city management personnel are in favor of flushing out the facility with clean wastewater (i.e. shutting off the flow of waste into the facility). However, the City Engineer is unsure about how long this will take and does not want to run the old facility for too long after the new one is built. The facility engineer has provided you with the following information: A diagram of a waste water treatment facility model; the volume and flow data pertinent to the East Rutherford treatment facility; and the estimated initial amount of pounds of waste in each tank.

The City Engineer would like each tank to be at 1% of their initial amount in ____ days. He would like all tanks cleaned and ready for shut down in ____ days.

Discuss whether or not the City Engineer will meet his timeline.

Support your answers analytically and graphically.



Volumes of Tanks:

Primary Settling Tank Volume: _____ gal.
Aeration Tank Volume: _____ gal.
Secondary Settling Tank Volume: _____ gal.

Flow Rates to/from Tanks:

R_{01}: _____ gal/hour
R_{12}: _____ gal/hour
R_{21}: _____ gal/hour
R_{23}: _____ gal/hour
R_{32}: _____ gal/hour
R_{30}: _____ gal/hour

Initial Conditions:

P(0) = _____ lbs
A(0) = _____ lbs
S(0) = _____ lbs