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RESERVE DESK

GEORGIA INSTITUTE OF TECHNOLOGY

The George W. Woodruff
School of Mechanical Engineering

Ph.D. Qualifiers Exam - Fall Semester 2000

Computer-Aided Engineering
EXAM AREA

Assigned Number (DO NOT SIGN YOUR NAME)

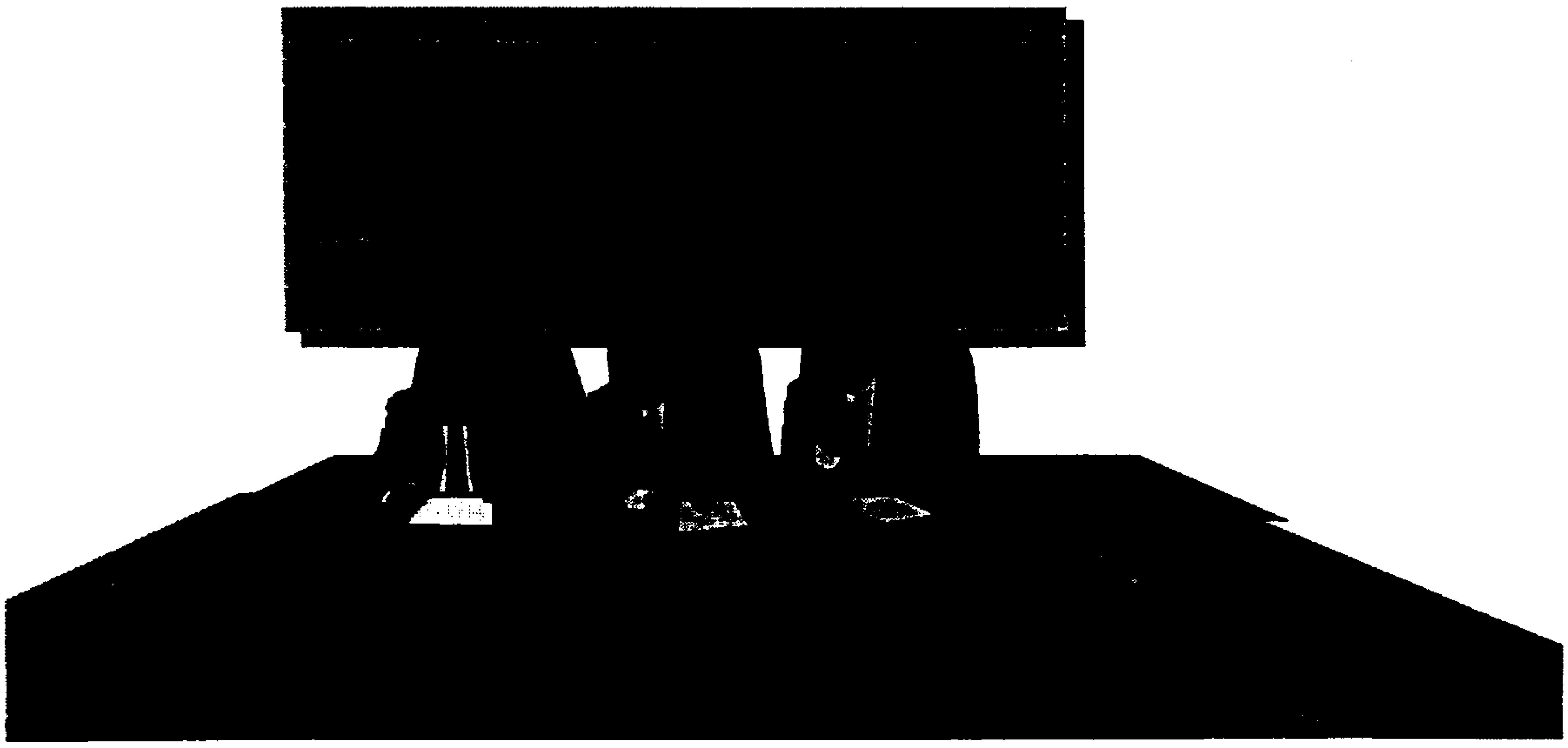
- **Please sign your name on the back of this page—**

COMPUTER-AIDED ENGINEERING

Ph.D. QUALIFIER EXAM - FALL 2000

THE GEORGE W. WOODRUFF SCHOOL OF MECHANICAL ENG.
GEORGIA INSTITUTE OF TECHNOLOGY
ATLANTA, GA 30332-0405

Fulton, Rosen, and Sitaraman (Chair)



- All questions in this exam have a common theme: ***Automotive Design***. The questions focus on different CAE aspects, as applicable to automobiles.
- Answer all questions.
- Make suitable assumptions when data is not available or when you do not follow a question. State your assumptions clearly and justify.
- Show all steps and calculations.
- ***During ORALS, you will be given an opportunity to tell us how CAE fits into your doctoral research. Please come prepared to make this opening statement.***

GOOD LUCK!

Question 1

Given

Equations for **Bezier curves** are

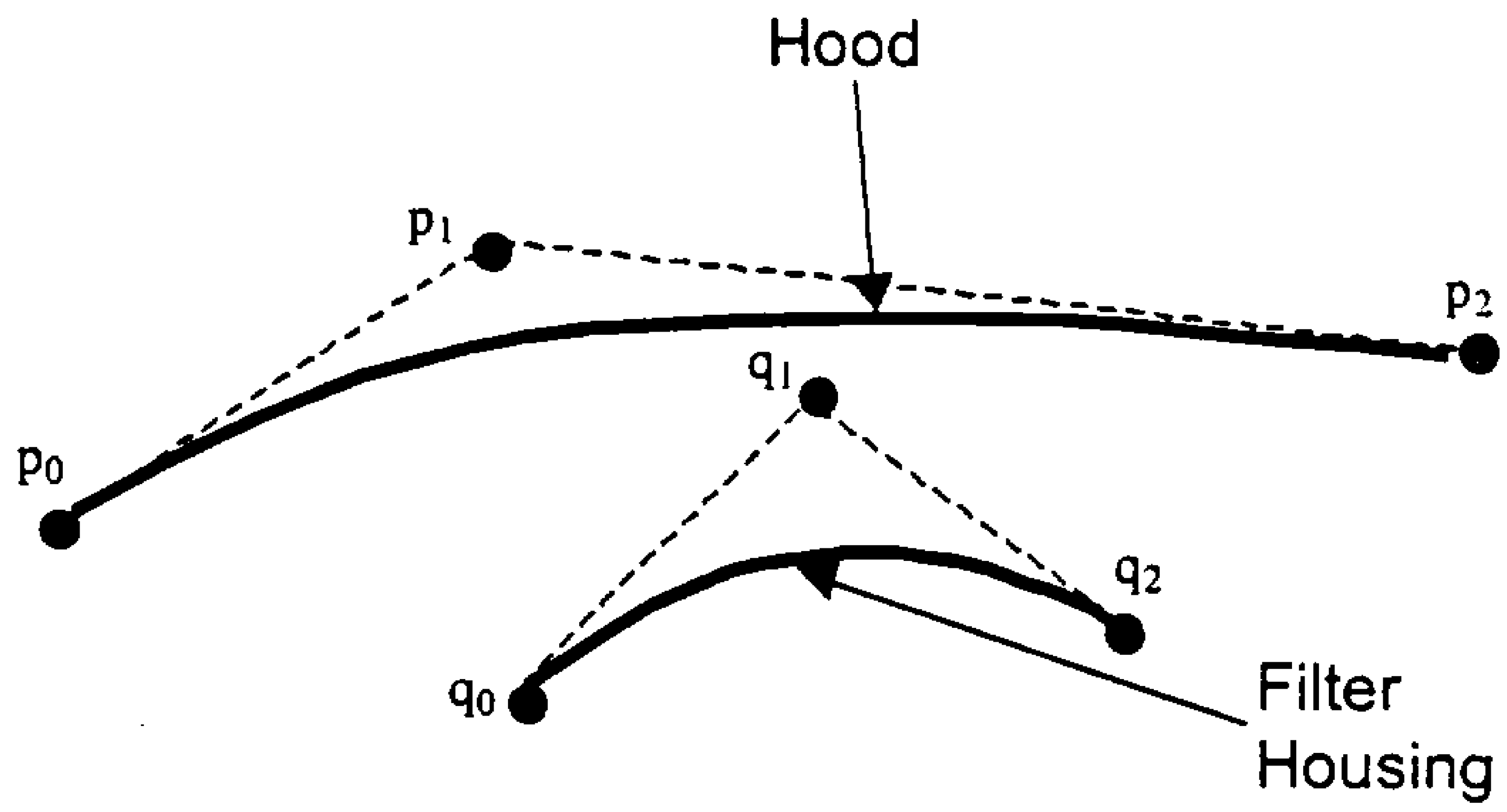
$$b(u) = \sum_{i=0}^{n} B_{i,n}(u)\vec{P}$$

where: **P** are the control vertices that define the Bezier curve.

$$B_{i,n}(u) = \binom{n}{i} u^i (1-u)^{n-i}$$

Questions

In the underhood area of a car, packaging components into the limited space is one of the most challenging aspects of designing cars. Avoiding intersections among components and providing clearances around components for cooling purposes is very important. This question deals with how to determine intersections and clearances among curved components.



Assume the hood is modeled by the top quadratic Bezier curve, while the air filter housing is modeled by the lower quadratic Bezier curve.

a) Assume that you are given the following three control vertices for the filter housing curve: $\mathbf{Q}_0 = (5,1)$, $\mathbf{Q}_1 = (8,3)$, $\mathbf{Q}_2 = (9, 0)$. Sketch the control polygon, then sketch in the curve.

b) Compute the X,Y point on the curve at u = 0.5.

There are a number of methods for computing intersections and clearances among parametric curves.

c) Assume that the control vertices for the hood are: $\mathbf{P}_0 = (3,1)$, $\mathbf{P}_1 = (8,2)$, $\mathbf{P}_2 = (11,0)$. Describe one method of computing the intersection among the hood and filter housing curves. Provide a step-by-step procedure. Identify any analytical or numerical methods that you would recommend to use.

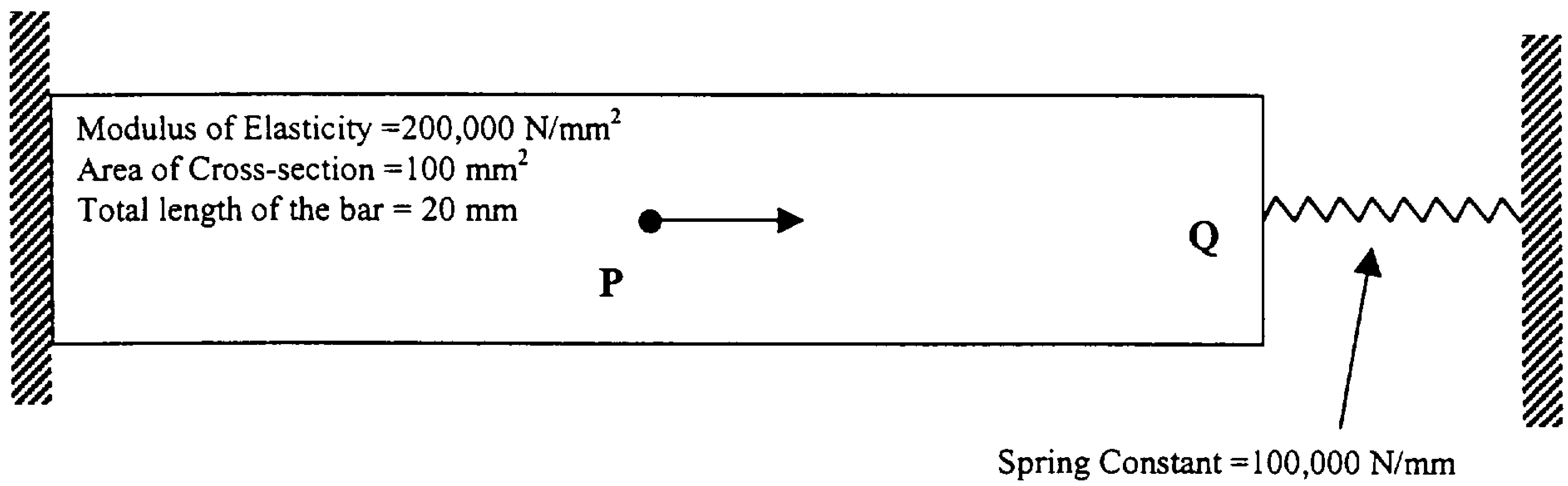
d) Attempt to apply your procedure to actually compute the intersection among the two curves. Explain any difficulties that you encounter. State any assumptions needed.

e) Now, assume that the hood curve is defined by control vertices: $\mathbf{P}_0 = (3,3)$, $\mathbf{P}_1 = (8,4)$, $\mathbf{P}_2 = (11, 2)$. Describe one method for computing the minimum clearance between the two curves. Again, provide a step-by-step procedure and identify any analytical or numerical methods that will help you solve this problem. You need not attempt to actually compute the clearance.

Question 2

A structural unit in the automotive contains an axial bar attached to a spring as shown in the figure below. The axial bar and the spring are constrained between two rigid supports. The properties of the axial bar and the spring are given in the figure. An axial force F of magnitude 10 kN is applied at the center of the axial bar (10 mm from the left rigid support) as shown in the figure. Using finite-element formulation,

- write down the stiffness matrix for each member
- assemble and write down the assembly stiffness matrix
- identify the boundary conditions
- determine the displacements at points P and Q. P is the midpoint of the axial rod, 10 mm from the left rigid support. Q is the tip of the axial rod, 20 mm from the left rigid support.
- determine the reaction forces at the two rigid end-supports

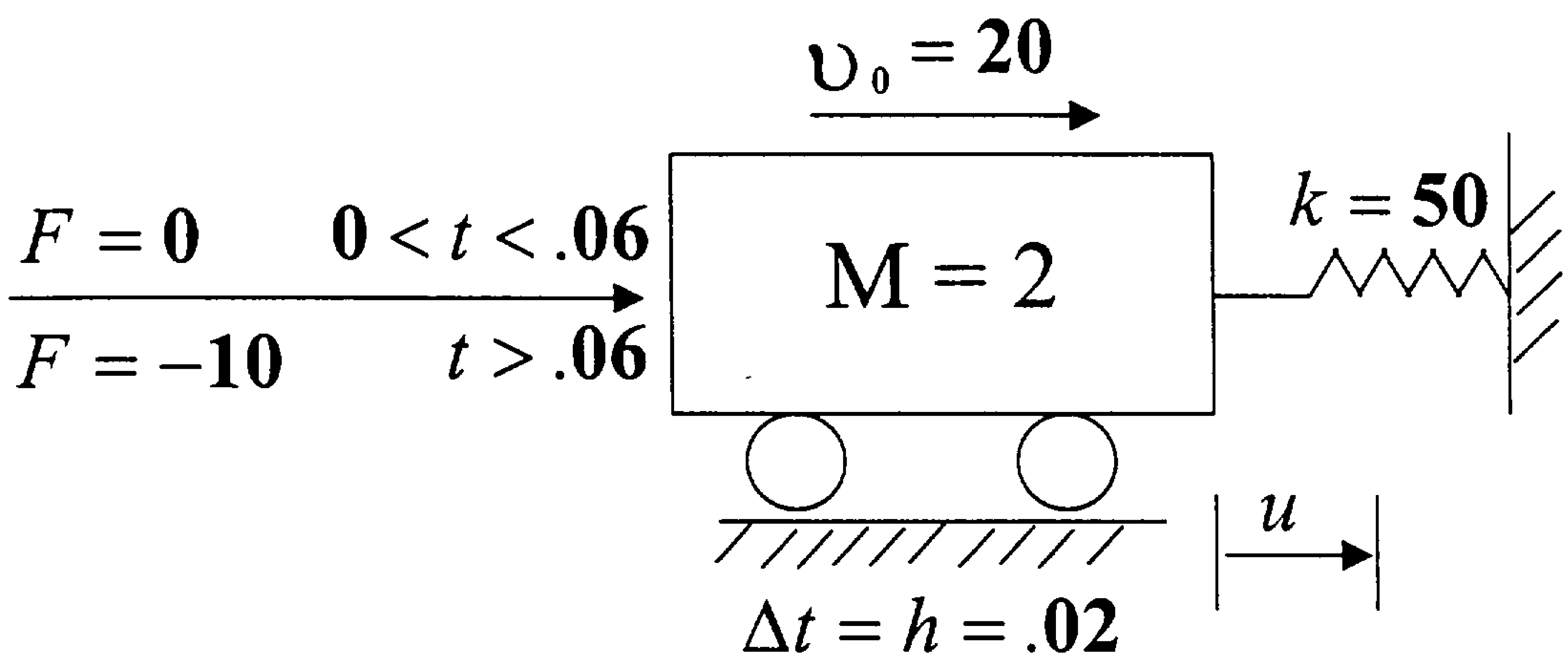


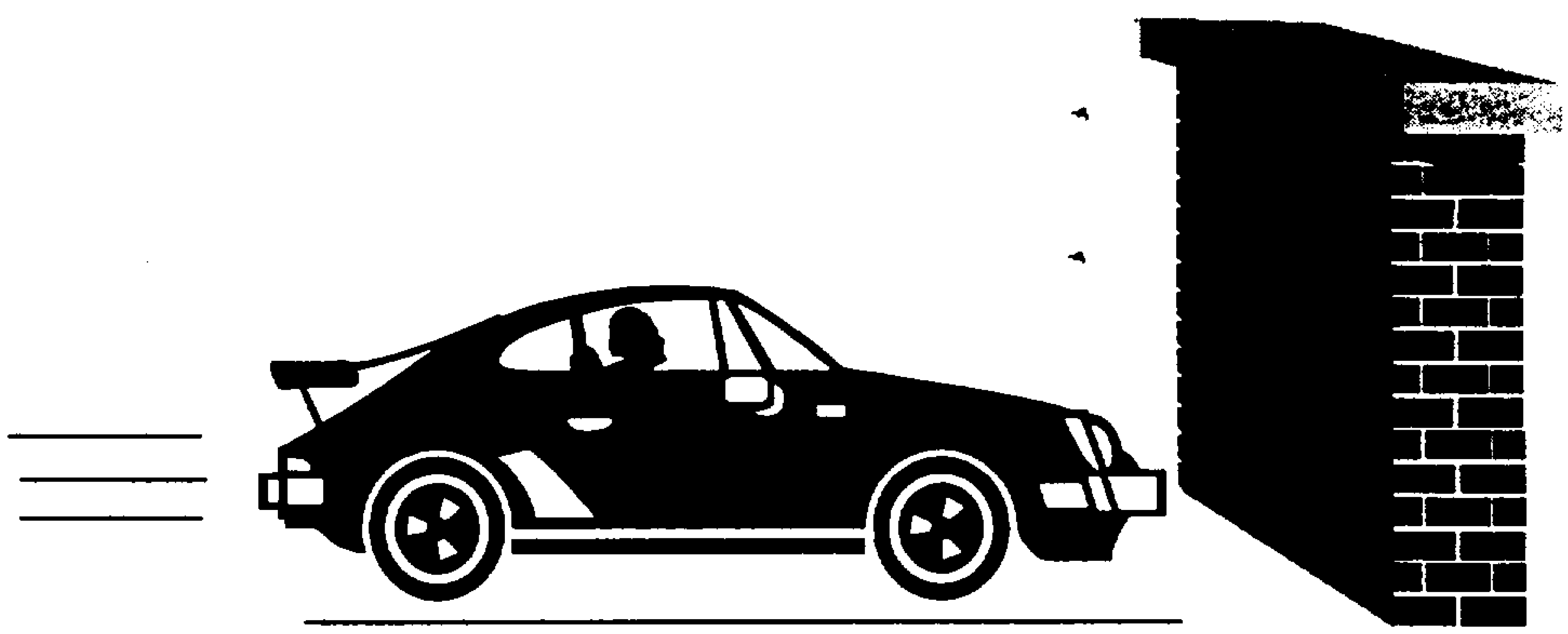
Assume that the whole structure is heated during operation and the temperature of the unit rises by 30 °C. Assume that the coefficient of the thermal expansion of the axial bar is $12*10^{-6}$/ °C and that of the spring is negligible.

- identify the boundary conditions
- outline a detailed procedure to solve for displacements and reaction forces. Outline all your steps and assumptions. You need not solve.

Question 3

An automobile of mass M is moving at a constant velocity of v_0 and hits a barrier that exerts a linear slowing force of Ku where K is the stiffness of the barrier and u is the displacement. This can be modeled as a mass spring system, as shown below. Use initial value numerical integration methods to obtain the velocity and how far the vehicle has gone after a time of 0.1. Let $\Delta t = h$ be 0.02. At $t=0.06$, a resisting force F of magnitude $F=-10$ kicks in to further slow the vehicle. Note that all quantities are dimensionless.





$$M\ddot{u}+Ku=F(t) \quad \text{where} \quad \ddot{u}=\frac{d^2u}{dt^2}$$