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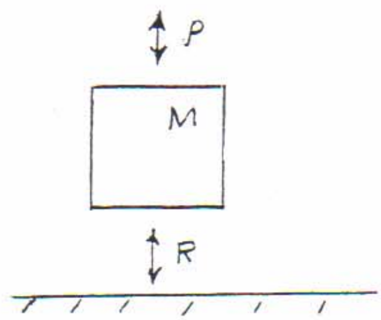
Examination, October 21, 1998

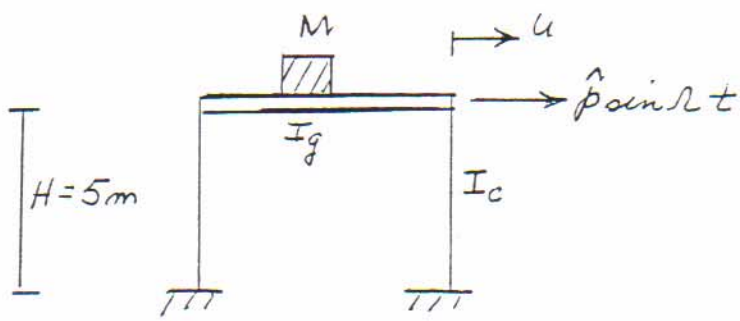
1.561 Motion-Based Design

PROBLEM #1



A piece of equipment having a mass of 10,000 kg is to be supported on a foundation. The equipment contains rotating devices which collectively produce a periodic vertical force having an amplitude of 1 kN and frequency of 6 Hz. The equipment is to be located adjacent to a micromanufacturing faculty which is very sensitive to ground disturbance. Suppose you are retained as a consultant to provide advice as to how the equipment should be supported. Discuss how you would respond. Illustrate your solution approach with some numerical results.

PROBLEM #2



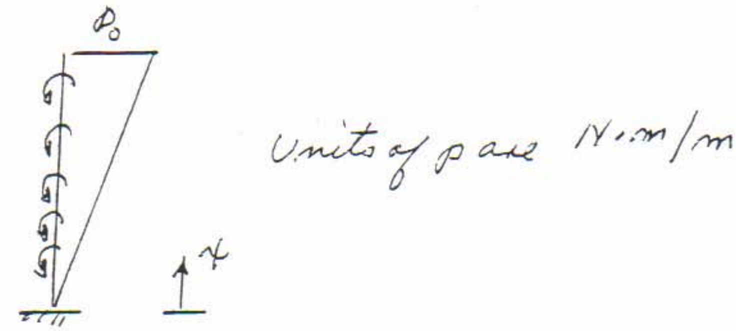
Consider a structural frame having a concentrated mass of 20,000 kg. Assume the girder is "infinitely" stiff in comparison to the columns. Suppose the frame is subjected to a lateral force which is periodic in time, and the design requirement is to limit the lateral displacement to be less than a specified value u^*. Recommend a value for the column moment of inertia for the following loading and response criteria. Assume the material is steel.

Case a: $\hat{p} = 10$ KN
$\Omega = \pi$ r/S
$u^* = 0.01$m

Case b: Same values for $\hat{p}$ and u^*
$\Omega = 3\pi$ r/s

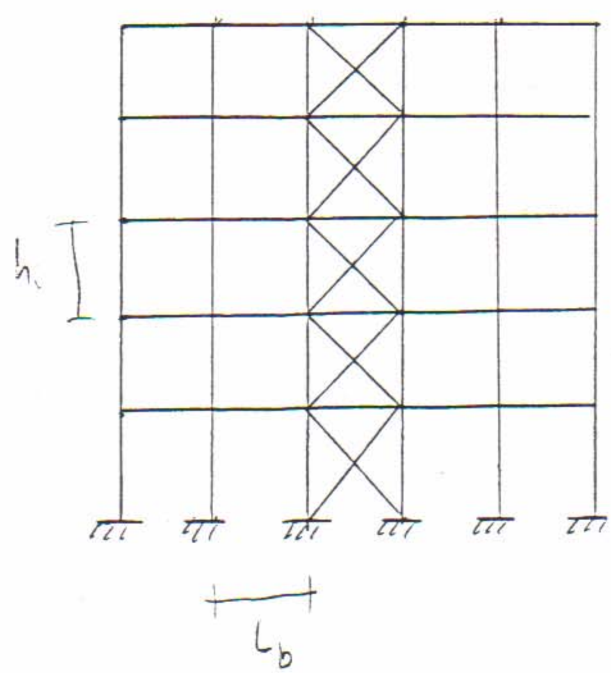
PROBLEM 3

Consider a cantilver beam acted upon by the distributed external moment, p(x) shown in the figure below. Assume the beam acts as a bending beam. Determine the bending rigidity distribution and magnitude such that the bending deformation is constant under this loading.



PROBLEM #4

Consider a five story rigid frame with diagonal bracing in one bay. Assume the mass per floor is the same for all the floors. The dominant loading for the building is seismic excitation (i.e., dynamic in nature). How would you select the cross-sectional properties for the columns and diagonal bracing contained in each story? How would you establish the "actual" values for these properties?



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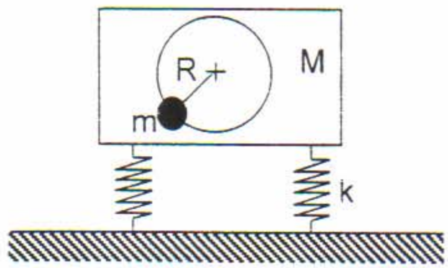
Examination, October 18, 1999

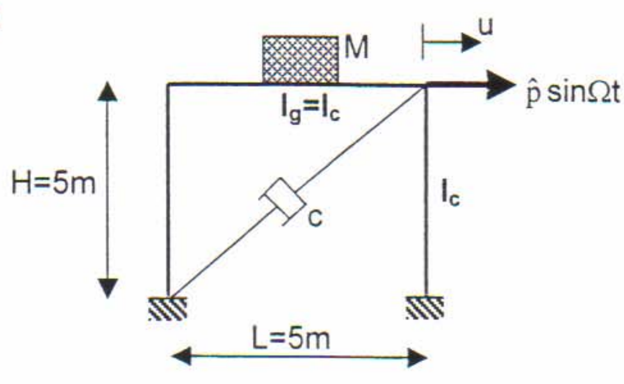
1.561 Motion-Based Design

PROBLEM #1



A piece of equipment in the geotechnical lab of the Civil and Environmental Engineering Department at MIT having a mass M of 10,000 kg is to be supported on a foundation. The equipment contains a mass m of 1000 kg rotating at a frequency of 60 rpm and having an eccentricity of R = 0.2m. The force capacity of the floor at the location of the foundation is P_{max}=800N. Recommend a value for the stiffness of the foundation.
Hint: The centrifugal acceleration of a mass rotating with frequency ω and radius R is $a=R\,\omega^2$

PROBLEM #2



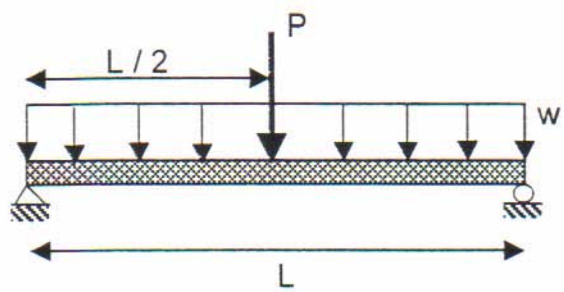
Consider a structural frame having a concentrated mass of 20,000 kg. Suppose the frame is subjected to a lateral force which is periodic in time, and the design requirement is to limit the lateral displacement to be less than a specified value u*. Recommend a value for the column moment of inertia for the following loading and response criteria. Assume the material is steel.

Case a:	$\hat{p}$ = 10 KN $\Omega = \pi$ r/S u* = 0.01m
Case b:	Same values for $\hat{p}$ and u* $\Omega = 3\pi$ r/S

Comment on how the required stiffness varies with damping.

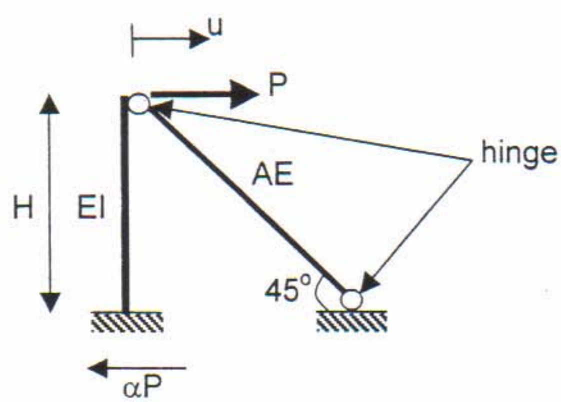
PROBLEM #3

Consider a simply supported bending beam subjected to the loading indicated in the figure below. Determine the distribution of the bending rigidity such that the curvature is constant.



PROBLEM #4

Consider a cantilever bending beam with a truss element connected as indicated in the following figure.



Determine the member stiffnesses such that the shear force in the cantilever beam is equal to αP.

Note: Consider only horizontal displacement of the node.

Massachusetts Institute of Technology

1.561 Exam I (Open Book)
October 17, 2000
11:00 - 12:30 am

PROBLEM #1 (40%)

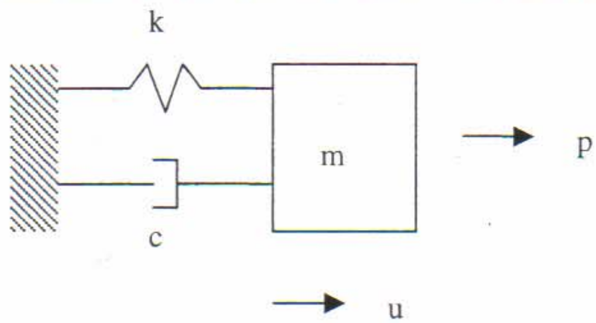
Consider a SDOF system having a mass equal to 1,000 kg. Suppose the system is subjected to a periodic excitation,

$$p = 1000\, Sin(\Omega t) \text{ Newtons}$$

where Ω can range from 10 Hz to 100 Hz, and the response is to be constrained such that the maximum velocity is equal to or less than a specific value v*, for the full range of excitation frequency. Consider 2 cases:

a) $v^* = 10^{-3}$ m/s
b) $v^* = 10^{-2}$ m/s

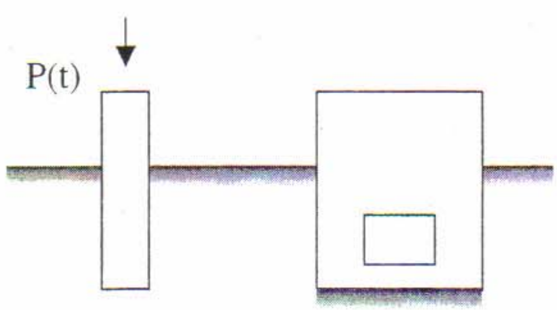
Discuss in detail the basis of your recommendations for k and c.



PROBLEM #2 (20%)

Consider the case where a pile-driving operation is being carried out adjacent to a building, as illustrated in the sketch. Suppose the driving force is periodic, with a frequency equal to 50 Hz. The basement of the building contains high precision measuring equipment, which is very sensitive to motion. The equipment has a mass equal to 10,000 kg.

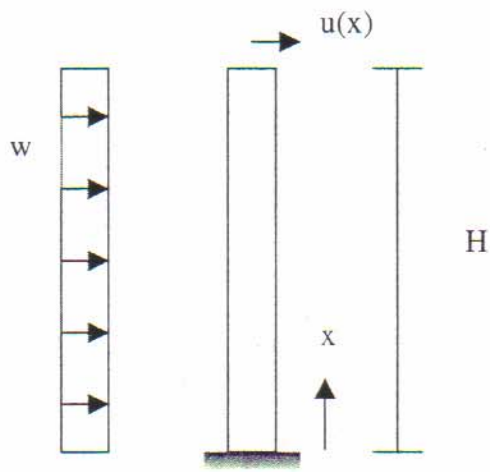
You are retained as a consultant by the owner of the equipment. What action would you recommend ? Discuss the basis for your recommendation.



PROBLEM #3 (30%)

Consider a tall building modeled as a cantilever bending beam. Suppose the design loading to be a uniformly distributed loading and the design objective is to select the bending rigidity distribution such that the curvature resulting from the uniform loading is constant over the height and the deflection at the tip of the beam satisfies the constraint

$$u(H) \leq \frac{H}{300}$$



Take

H = 200 meters, and
w = 1 KN/meter

a) Determine D_B (x)
b) Suppose the maximum value of D_B that can be provided by the beam is

$$D_{B\,max} = 4 \times 10^{11} \,(\mathrm{N\,m^2})$$

Describe how would you provide the additional bending rigidity with an outrigger system. Specify the location and parameters for the outrigger system.

PROBLEM #4 (10%)

Consider the cantilever beam/spring system shown in the sketch. Suppose the system is subjected to the static loading b(x).

Describe how would you specify the bending rigidity distribution, D_B (x), and the spring stiffness such that the curvature due to b(x) is constant.