Entrance Examination for the 2013,

Department of Civil Engineering,

Graduate School of Engineering, the University of Tokyo

Problems of "Civil engineering"

August 27th 2012 (Monday) 13:00 - 16:00 (180 minutes)

(Fields 2, 3, 4, 5 and 7 are not provided in English.)

Please write your answer to problems in two fields which you have selected on questionnaire sheet. If you answer problems in different fields, your answer shall not be marked.

Please use different answer sheets for different problems (Problem 1, Problem 2). For each of answer sheet you have, please fill your examinee's number, field number, and problem number (e.g. Field 1, Problem 1).

You can use the reverse side of answer sheets. When you require additional answer sheets for fields 1 to 6, please raise your hands. If you use multiple answer sheets for one problem, please put sheet number. You can ask additional answer sheets for calculation.

You have to submit problems, questionnaire sheet, and all answer sheets (including blank sheets or ones for calculation) after the examination.

For Field 7 (Mathematics), please select 2 problems out of 6 problems. Please note that special answer sheets are provided for field 7 and that you cannot use additional answer sheets for field 7.

Field 1 (Structures)

Problem 1

Consider a beam which has the elastic modulus (Young's modulus) E, the second moment of area I, and the span L. The beam is simply supported at the both ends.

(1) Suppose that the beam is subjected to uniform loading of p. Write a boundary value problem for the displacement of the beam, denoted by w. Here, we take the x-axis along the beam, starting from $x = 0$ to $x = L$. p is the vertical force per unit length, and w is the displacement component in the vertical direction. You do not have to derive a boundary value problem, which consists of a differential equation and boundary conditions.

(2) Suppose that a part of the beam is deteriorated. Model this deterioration as the decrease in the elastic moduli. That is, E which is a constant is changed to a function of x. Re-denoting this elastic modulus by $E(x)$, rewrite the differential equation of the boundary value problem of (1).

(3) Is the distribution of moment of the beam changed after the deterioration? Answer yes or no first, and then explain the reason of your answer briefly.

(4) Is the total elastic energy stored in the beam increased after the deterioration? First, define the total elastic energy. Then, answer yes or no, with brief explanation of the reason of your answer. You do not have to include work done by p in the total elastic energy.

Problem 2

A passenger car could be modeled as a single-degree-of-freedom system shown in the Figure 1, with the known mass m, the spring constant k, and the damping c. $y(t)$ denotes the absolute vertical displacement of the mass, and $u_g(x)$ represents the surface shape of the road. t and x denote the time and the position coordinate in the moving direction, respectively. The moving speed v of the car is constant, therefore $x=vt$. Answer the following questions.

(1) As shown in the Figure 1, the car is moving on the virtual road surface which is expressed as $u_g(x) = a\sin(\omega x)$. Using $x=vt$, derive the equation of motion of this system.

(2) Find the steady-state response of $y(t)$ under the condition of question (1). Here, the answer may be simplified by using the natural frequency of the car $\omega_0 = \sqrt{k/m}$, damping ratio $\xi = c/(2m\omega_0)$ and the ratio of frequencies $\lambda = v\omega/\omega_0$.

(3) Under the condition of question (1), the maximum displacement of the passenger car is denoted by y_m, and then define η as $\eta = y_m/a$. Draw η with respect to the $\lambda\,(0 \le \lambda < \infty)$ in the cases of $\xi = 0$ and $\xi = 1/3$. In addition, find the values of λ when η is independent of ξ.

(4) As shown in Figure 2, the surface shape of the road is represented by the equation (1). When $t < 0$, the car is not vibrating. Obtain $y(t)$ in the range $0 < t < 2\pi/\omega_0$. Here, assume $d\omega_0/v$ is small enough that the load could be considered as impulsive loading. Damping does not need to be considered (i.e., $c = 0$).

$$u_g(x) = \begin{cases} b\sin\left(\dfrac{\pi x}{d}\right) & (0 \le x \le d) \\ 0 & (d < x \le d + \dfrac{\pi v}{\omega_0}) \\ b\sin\left[\dfrac{\pi}{d}\left(x - d - \dfrac{\pi v}{\omega_0}\right)\right] & (d + \dfrac{\pi v}{\omega_0} < x \le 2d + \dfrac{\pi v}{\omega_0}) \\ 0 & (2d + \dfrac{\pi v}{\omega_0} < x) \end{cases} \tag{1}$$

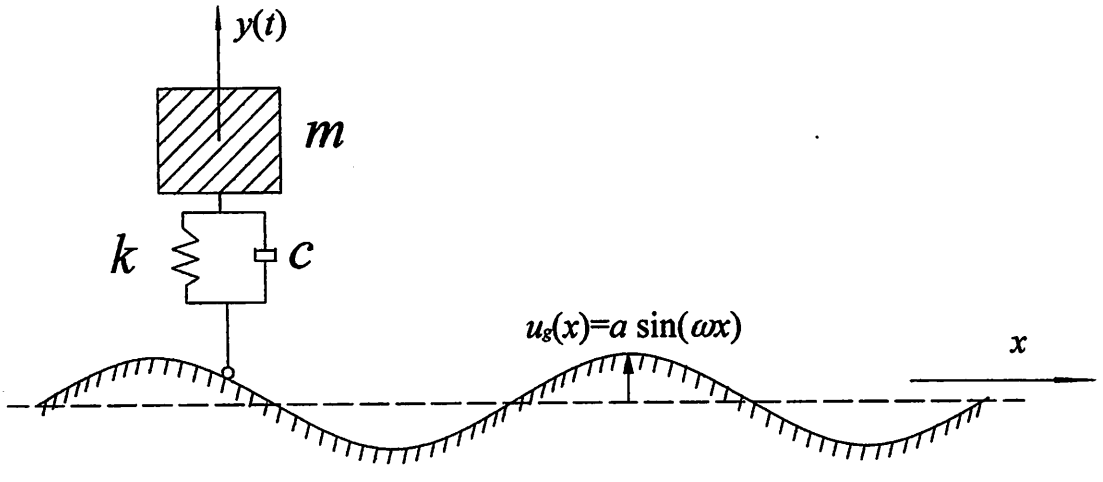

Figure 1

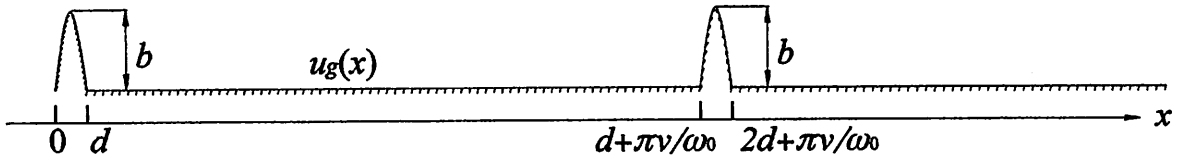

Figure 2

Field 6 (International Project and Management)

Problem 1

A prefectural road public corporation aims to deliver a good toll-road service to the users in a way that enables to redeem bonds for construction costs and to provide appropriate maintenance services. The public corporation is also investigating ways to improve its management.

Answer the following questions.

(1) Originally, the public corporation used to apply the negotiated procedure for the procurement of toll collection services. Explain, in approximately five lines, the potential outcomes and issues to be considered if the open competitive tendering process is applied instead.

(2) The public corporation contracts out small packages of maintenance and repair works as they become necessary based on results of inspections. Explain, in approximately five lines, how can generally maintenance contracts be improved and what potential outcomes can be expected as a result of such improvements.

(3) Due to the aging of infrastructure facilities, such as bridges or tunnels, an increase in maintenance expenditures is expected in the future. Describe, in approximately five lines, the main points of a long-term maintenance plan based on the concept of asset management in order to cope with this problem.

(4) Finally, to improve the management of the public corporation, the possibility of involving the private sector in operation and maintenance by transferring usage rights of infrastructure facilities to private organizations is being considered. Draw a diagram of the relations among main players in such project schemes and explain the main features of such arrangements in approximately five lines.

Problem 2

Answer the following questions.

(1) Answer the following questions regarding poverty and inequality.

a) Describe the expected impacts of inequality with respect to income level in a given country on the national economic growth in approximately five lines. Use the following terms for your explanations: "Gini Index," "Kuznets," and "trickle down."

b) Raise two problems in using the income level for evaluating the poverty and explain them in approximately three lines for each.

c) United Nations Development Programme (UNDP) has proposed Human Development Index (HDI) as an alternative to the income level. This is a comprehensive socio-economic index for measuring the level of human development in each nation. Show three components to calculate this index.

(2) Recently a new construction technology, Labor-based Technology (LBT) has become popular for road construction at rural areas in developing regions such as Africa. LBT is a labor-intensive technology where the road is constructed using the human power with small-scale agricultural devices such as a tractor, a hoe, a plow, etc. Raise three advantages in using this technology and explain them in approximately three lines for each.