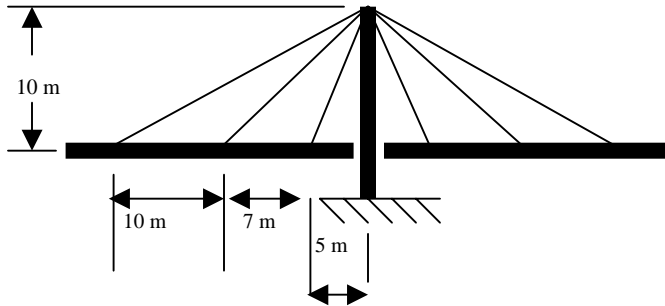


“What is Engineering” sample exam

STATICS

Consider the following symmetrical cable-stayed structure:



Each horizontal beam weighs 1000 kgs (weight) and is supported entirely by the cables. Each cable is tuned to support exactly $\frac{1}{3}$ the weight of the beam.

- How much tension is there in each cable?
- How much compressive load is there on the vertical stay (from both beams)?
- How much side load does each beam impart to the vertical stay?

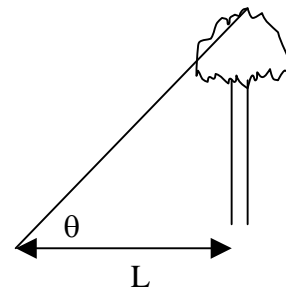
MATERIALS

A single rod of iron has an Euler buckling strength of 100 Newtons. If you bond together seven such rods in the following two configurations, what will be their buckling strengths? Explain your answers?

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MEASUREMENT

3) You indirectly measure the height of a tree to be $H = 10\text{m}$ using distance L and angle θ . You know you could have a potential error $\Delta L = 0.1\text{m}$ and $\Delta\theta = 0.1$ radians. You're interested in finding the location which minimizes your potential error ΔH in estimating the height of the tree. Find this location in one of two ways: 1) analytically deduce this location, or 2) produce a series of L, θ values which gives a height of 10m; then, using Excel, generate a plot of ΔH vs L to observe the best location.



Solution: $H = L \tan\theta \Rightarrow \Delta H = \Delta L \tan\theta + L \sec^2\theta \Delta\theta$

$$\frac{\partial\Delta H}{\partial\theta} = \Delta L \sec^2\theta + 2L \Delta\theta \sec^2\theta \tan\theta = 0 \Rightarrow \Delta L + 2L \Delta\theta \tan\theta = 0$$

$$\frac{\partial\Delta H}{\partial L} = \sec^2\theta \Delta\theta = 0$$

LOGIC

In many banks today you must pass through two locked doors, say A and B. And only one can be open at a time. Design a control circuit consisting of only NAND gates that will open door A when button A is pressed and will open door B when button B is pressed, but will do nothing if both buttons A and B are pressed simultaneously.

ESTIMATION

Estimate how many Grand Canyons it would take to hold the entire world population. People can be bunched together as closely as possible.

DIFFUSION/CONDUCTION

Consider a metal rod made from aluminum (thermal conductivity $K = 119$) and silver ($K = 238$): [K has units $\text{BTU}/(\text{hr})(\text{ft}^2)(^\circ\text{F}/\text{in.})$]

Al	Ag
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The rod is initially at a temperature $T = 0$. At time $t = 0$ the left side of the rod is held at $T = 100$; the right side is held at $T = 0$. Sketch the temperature profile at a very long time. Describe quantitatively the features of this asymptotic state.

DIMENSIONAL REASONING

When you're in a moving car and you stick your hand out the window, you feel wind pressure which depends on the speed of the car. When you're in a moving boat and you stick your hand into the water, you feel water pressure, which depends on the speed of the boat. Using dimensional reasoning, devise a functional relationship for pressure in terms of velocity and fluid density.

Your company makes medium size ball bearings and you're in charge of monitoring the variation in size. Since you know the density of the steel involved and the bearings are perfectly spherical, you can either weigh a sample or measure its diameter.

Unfortunately your measurement instruments are not perfect: your scale has accuracy to ΔW and your vernier caliper has accuracy to ΔL . With these medium size ball bearings it makes no difference which measurement method you use, because finding the weight from a diameter measurement with error ΔL produces the same inaccuracy as a direct

measurement of weight with error ΔW . But now your company wants to begin manufacturing small and large ball bearings as well. To obtain the better measurement of these two new lines, what measurement technique should you use? Does it make any difference?

COMMUNICATION

Produce a one-page set of instructions for tying one's shoelace. Use text and/or sketches as needed.

CHEMICAL PROCESSES

The process of distillation can produce high-concentration alcohol/water mixtures out of low-concentration mixtures. If you begin with an alcohol/water mixture of 5%, how many successive stages of distillation would be required to produce an 80% concentration of alcohol? (Refer to the McCabe-Thiele chart in the chemical processes lab instructions. Look up how you can use this chart to graphically answer this question.) Assume that the efficiency of each stage is 100%. What is the maximum concentration of alcohol you can obtain from distillation? Find out what must be done to obtain pure alcohol.

STATISTICS

The distance between two radio antennas has been measured by ten different people to be (in meters): 146.4, 148.2, 144.7, 146.3, 149.0, 148.4, 147.3, 143.3, 145.5, 150.1. Assume that each measurement is equally valid. What's your best guess as to the actual distance between the antennas? What's the standard error of your estimate? How many more measurements would have to be taken to reduce the standard error by a factor of 10?