1. (25%) The I-beam shown in Fig. 1 is a W8 x 40 structural steel (E = 29,000 ksi) wide-flange section (see table below). Determine
   a. The equation of elastic curve for the region of the beam between the supports. Use the designated coordinate.
   b. The deflection midway between the supports if w = 240lb/ft and L=16 ft. (10%)

Designation*	Area (in.²)	Depth (in.)	Flange Width (in.)	Flange Thickness (in.)	Web Thickness (in.)	Axis X–X I (in.⁴)	Axis X–X S (in.³)	Axis X–X r (in.)	Axis Y–Y I (in.⁴)	Axis Y–Y S (in.³)	Axis Y–Y r (in.)
W10 × 60	17.6	10.22	10.080	0.680	0.420	341	66.7	4.39	116	23.0	2.57
× 45	13.3	10.10	8.020	0.620	0.350	248	49.1	4.33	53.4	13.3	2.01
× 30	8.84	10.47	5.810	0.510	0.300	170	32.4	4.38	16.7	5.75	1.37
× 22	6.49	10.17	5.750	0.360	0.240	118	23.2	4.27	11.4	3.97	1.33
W8 × 40	11.7	8.25	8.070	0.560	0.360	146	35.5	3.53	49.1	12.2	2.04
× 31	9.13	8.00	7.995	0.435	0.285	110	27.5	3.47	37.1	9.27	2.02
× 24	7.08	7.93	6.495	0.400	0.245	82.8	20.9	3.42	18.3	5.63	1.61
× 15	4.44	8.11	4.015	0.315	0.245	48.0	11.8	3.29	3.41	1.70	0.876
W6 × 25	7.34	6.38	6.080	0.455	0.320	53.4	16.7	2.70	17.1	5.61	1.52
× 16	4.74	6.28	4.030	0.405	0.260	32.1	10.2	2.60	4.43	2.20	0.967
W5 × 16	4.68	5.01	5.000	0.360	0.240	21.3	8.51	2.13	7.51	3.00	1.27
W4 × 13	3.83	4.16	4.060	0.345	0.280	11.3	5.46	1.72	3.86	1.90	1.00

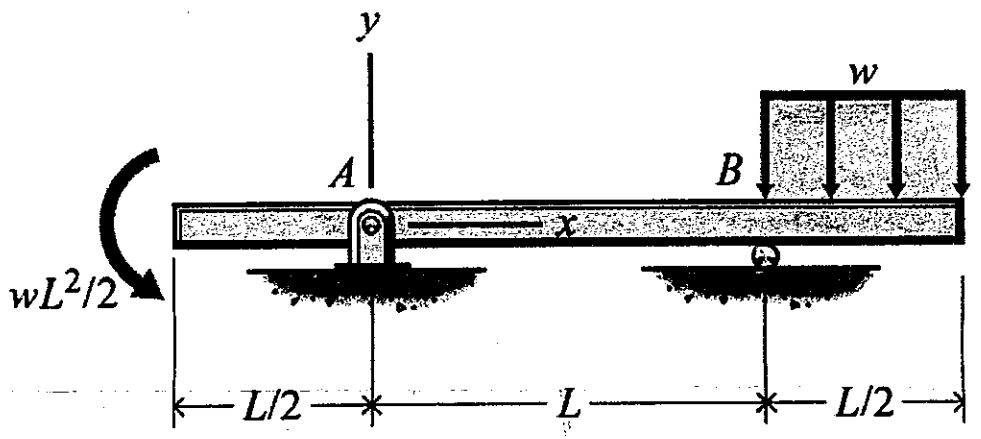

Fig. 1

2. (25%) A thin-walled cylindrical pressure vessel with an inside diameter of 4 ft is fabricated by butt-welding 0.6-in.-thick plate with a spiral welding as shown in Fig. 2. The pressure in the tank is 300 psi. Additional loads are applied to the cylinder through a rigid end plate. Please determine
   a. The normal and shearing stress on the plane of the weld at a point on the outside surface of the tank.
   b. The principle stresses and maximum shear stress at a point on the inside surface of the tank.

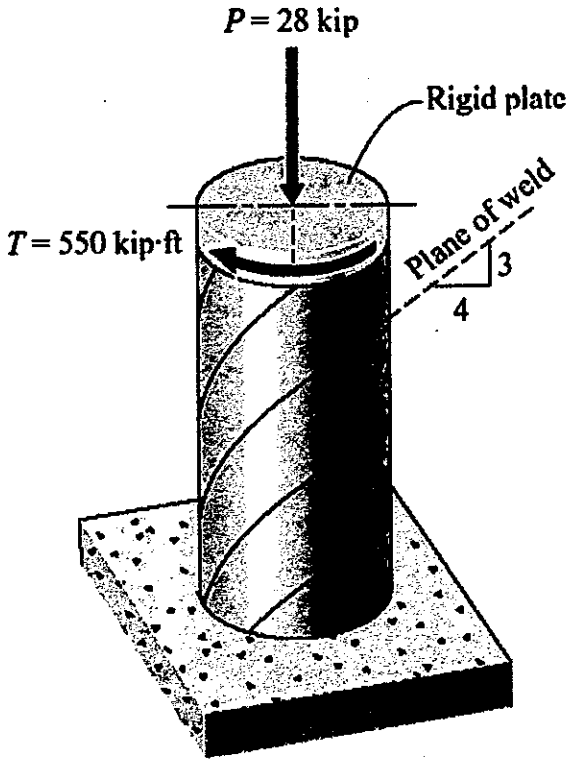

Fig. 2.

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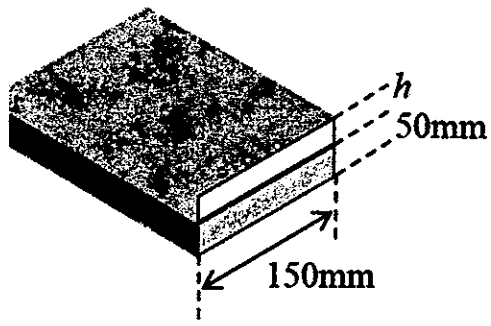
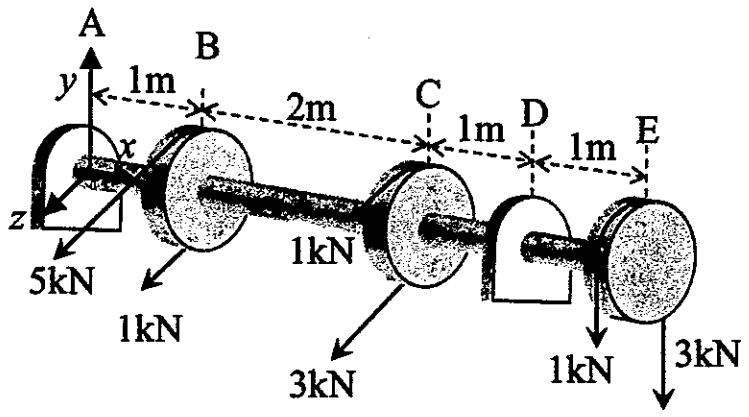
3. (20%) Consider a two-layer composite beam made of brass (top layer) and aluminum (bottom layer). The corresponding young's modulus are 100 GPa and 70 GPa. The thickness of the aluminum layer is 50 mm, and the thickness of the brass layer is *h*. The width of this composite beam is 150mm. Please answer the following questions.
   (A) Determine the thickness *h* of the brass layer so that the neutral plan is located at the interface of these two layers.
   (B) Based on your solution in (A), calculate the moment of inertia *I*.
   (C) Assume the maximum allowable bending stress for aluminum and brass are 130Mpa and 30MPa, respectively. Please identify the maximum moment.



4. (30%) Consider a solid shaft loaded with 3 pulleys at positions B, C, and E. All of their radii are 0.15 m. This shaft is supported by two frictionless bearing at position A and D. Please answer the following questions.
   (A) Show the free-body diagram of the shaft.
   (B) Draw the moment diagrams of M_x, M_y, and M_z.
   (C) Use your results in (B) to calculate the required diameter *d* of the shaft according to the maximum shear stress theory. (Assume τ_{total} is 70 MPa.)
   (D) Based on your calculation in (C), please identify the critical position.



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