共四题(第一题 20%，第二题 30%，第三题及第四题各 25%)

(1) A steel ball (or wind damper, see figure) is hung from the 92\textsuperscript{nd} floor to the 87\textsuperscript{th} floor in Taipei 101. The ball weighs 680 tons (1 ton = 1000 kg). 16 cables are used for hanging this ball. The length of each cable is 40 m and the diameter of each of the cable is 89 mm. Each cable has an effective modulus of elasticity $E = 150$ GPa and an effective area $A = 3792$ mm$^2$.

(1-a) How much will each of the cables stretch (in the unit of mm) after the 16 cables are loaded by the ball? (10%)

(1-b) If each of the cable is rated for a maximum load of 5200 kN, what is the factor of safety with respect to failure of the cable? (10%)
(Note that not all the cables are shown in the figure. Please do not count the number of the cables directly from the figure. Use the number given in the problem description instead.)

(2) The rotating solid steel shaft is simply supported by bearings at points $B$ and $C$ and is driven by a gear (not shown) which meshes with the spur gear at $D$, which has a 120-mm pitch diameter. The force $F$ from the drive gear acts at a pressure angle of 20°. The shaft transmits a torque $T_A$ to point $A$.

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\sin 20^\circ = 0.34, \quad \cos 20^\circ = 0.94
\]

(2-a) Draw the shear force diagram (one diagram only) for the shaft and specify the maximum and minimum values of the shear force. Express your answer in terms of $T_A$. (10%)

(2-b) Draw the bending moment diagram (one diagram only) for the shaft and specify the maximum and minimum values of the bending moment. Express your answer in terms of $T_A$. (10%)

(2-c) Assume $T_A$ to be 10 N-m and the shaft diameter to be 15 mm. Determine the maximum tensile stress $\sigma_t$ (in the unit of MPa) acting on the shaft. (5%)

(2-d) Assume that the shaft transmits 20.4 kW at 650 rpm to point $A$. What is the value of $T_A$? (5%)
(3). A disk rolls without slipping and at a given instant has the angular motion shown. Determine, at this instant, (a) the absolute velocity and acceleration of peg A (10%), (b) the angular velocity and angular acceleration of the slotted link BC (15%). The peg at A is fixed to the disk.

![Diagram of a disk rolling without slipping with dimensions labeled: \( \omega = 2 \text{ rad/s} \), \( \alpha = 4 \text{ rad/s}^2 \), and a length of 1 m.]

No slipping

(4). A 2-kg sphere moving to the right with a velocity of 5 m/s strikes at A. The surface of a 9-kg quarter cylinder which is initially at rest and in contact with a spring of constant 20 kN/m. The spring is held by cables so that it is initially compressed 50 mm. Neglecting friction and knowing that the coefficient of restitution is 0.6, determine (a) the velocity of the sphere immediately after impact (15%), (b) the maximum compressive force in the spring (10%).

![Diagram of a sphere colliding with a quarter cylinder with a velocity of 5 m/s and a spring compressed by cables.]