ME311 Quiz 2/3

本试卷共（4）大题，满分（100）分，请用中文或英文作答，将答案单独写在答题纸上，在答题纸右上角标注姓名学号。

There are 2 problems in total for 100 points. Write answers in a separate sheet in Chinese or English. Identify your name and student number on the top right corner of your answer sheets.

1、（10 分）请描述渐开线斜齿圆柱齿轮齿廓（或齿面）形成的过程，其传动特点与渐开线直齿圆柱齿轮有何区别，适用场景有何不同？

1、（10points）Describe the process of forming the tooth profile (or tooth face) of an involute helical cylindrical gear, how its transmission characteristics differ from those of an involute straight cylindrical gear, and what are the different applications?

参考答案：

（1） 渐开线直齿圆柱齿轮齿廓（或齿面）的形成：

当发生面沿基圆柱做纯滚动时，平行于齿轮轴线的直线 KK’在空间的轨迹为直齿圆柱齿轮的齿面

Formation of the tooth profile (or tooth face) of an involute straight-toothed cylindrical gear:

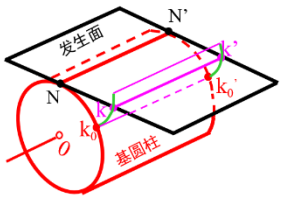
When the occurrence of the surface along the base cylinder to do pure rolling, parallel to the gear axis of the straight line KK’ in the space of the trajectory for the straight-toothed cylindrical gear tooth surface

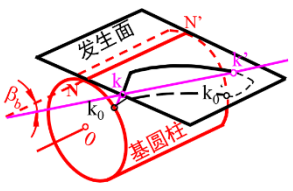
渐开线斜齿圆柱齿轮齿廓（或齿面）的形成：

与基圆柱的母线成一夹角β_b的直线 KK’在空间的轨迹形成 斜齿圆柱齿轮的渐开螺旋面

Involute helical cylindrical gears Involute helical cylindrical gears Formation of tooth profile (or tooth face):

The trajectory in space of a straight line KK' making an angle β_b with the base cylinder's busbar forms the involute helical face of a helical helical gear.





渐开线直齿圆柱齿轮齿廓（或齿面）的形成　　渐开线斜齿圆柱齿轮齿廓（或齿面）的形成

（2）　传动特点：

渐开线直齿圆柱齿轮的传动特点：一对直齿轮啮合时，沿整个齿宽同时进入啮合，并沿整个齿宽同时脱离啮合。因此传动平稳性差，冲击噪声大，不适于高速传动。

Involute straight cylindrical gear transmission characteristics: when a pair of spur gears mesh, along the entire width of the teeth at the same time into mesh, and along the entire width of the teeth at the same time out of mesh. Therefore, the transmission smoothness is poor, impact noise, not suitable for high-speed transmission.

渐开线斜齿圆柱齿轮的传动特点：一对斜齿轮啮合时，齿面上的接触线出现由短变长，再由长变短，减少了传动是的冲击和噪音，提高了传动稳定性，故斜齿轮适用于重载、高速传动。

Transmission characteristics of involute helical cylindrical gears: when a pair of helical gears mesh, the contact line on the tooth surface appears to change from short to long, and then from long to short, which reduces the transmission is the impact and noise, and improves the transmission stability, so helical gears are suitable for heavy-duty, high-speed transmission.

（3）　适用场景：

渐开线直齿圆柱齿轮：适用于低速，轻载/中载场景
渐开线斜齿圆柱齿轮：适用于高速，重载场景。
Involute Straight Cylindrical Gear: For low speed, light/medium load scenarios.
Involute helical cylindrical gears: for high speed, heavy duty scenarios.

2、（30 分）在蜗杆 - 斜齿圆柱齿轮传动装置中，已知输入轴 I 上的右旋蜗杆 1 的转动方向如图所示。欲使轴 II 上的两轮的轴向力抵消一部分：

(1) 确定蜗轮 2、齿轮 3 和齿轮 4 的螺旋角方向是左旋还是右旋。

(2) 在图上标出蜗轮 2 和齿轮 3、4 的转动方向。

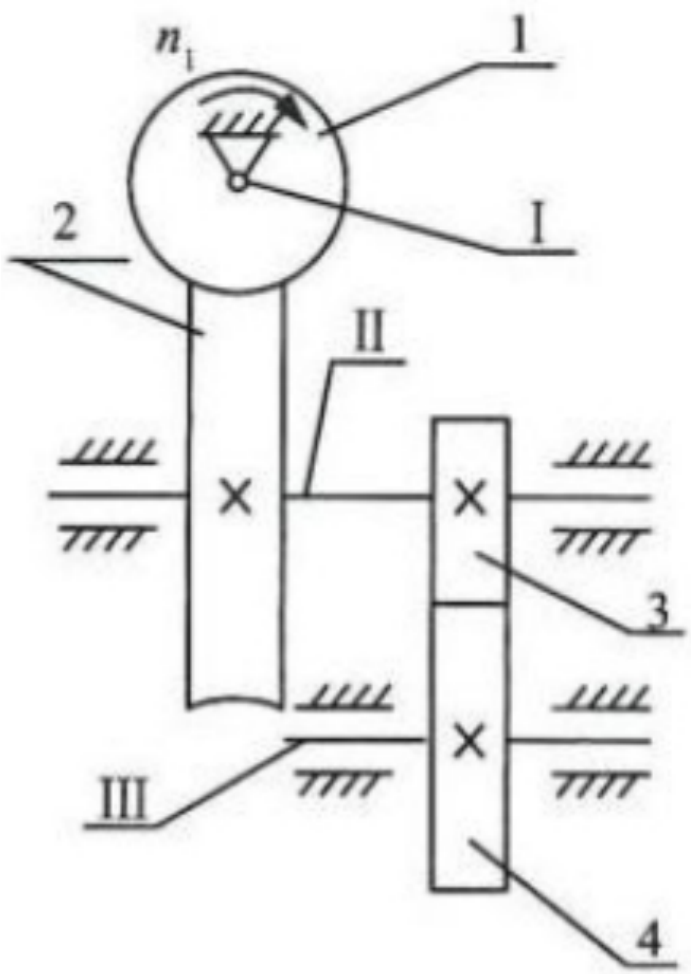
(3) 在图上标出蜗杆 1、蜗轮 2 和齿轮 3、4 的圆周力F_t、轴向力F_a的方向。

2、（30points）In the worm-helical gear transmission, the rotation direction of the right-handed worm 1 on the input shaft I is known as shown in the figure. To offset part of the axial force of the two wheels on shaft II:

(1) Determine whether the helix angle direction of worm wheel 2, gear 3 and gear 4 is left-handed or right-handed.

(2) Mark the rotation direction of worm wheel 2 and gears 3 and 4 on the figure.

(3) Mark the direction of the circumferential force Ft and axial force Fa of worm 1, worm wheel 2 and gears 3 and 4 on the figure.



参考答案：

分析题意知，由蜗杆旋向和转向，根据右手原则得出蜗杆 1 的轴向力和圆周力方

向，从而判断出蜗轮 2 的轴向力、圆周力方向、旋向和其转向。为了使 II 轴上的力抵消一部分，则蜗轮 2 受的轴向力 F_{a2} 方向和齿轮 3 所受的轴向力 F_{a3} 方向相反。在此基础上,再根据左右手原则判断齿轮旋向。

Analyzing the question, we know that the axial force and circumferential force direction of worm 1 can be obtained according to the right-hand principle from the worm rotation direction and direction, and thus the axial force, circumferential force direction, rotation direction and direction of worm wheel 2 can be determined. In order to offset part of the force on axis II, the axial force F_{a2} on worm wheel 2 is in the opposite direction to the axial force F_{a3} on gear 3. On this basis, the gear rotation direction can be determined according to the left-right hand principle.

The rotation direction of worm wheel 2 is the same as that of worm 1, that is, right-handed. In order to offset part of the axial force, the rotation direction of gear 3 should be opposite to that of worm wheel 2, that is, right-handed, and the rotation direction of gear 4 should be opposite to that of worm wheel 2, that is, left-handed.

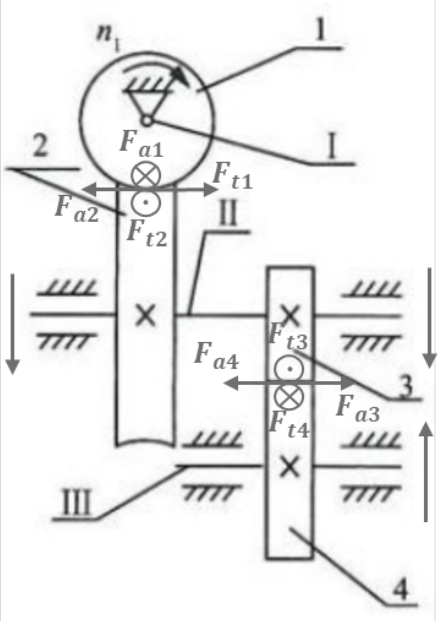
根据上述分析与受力情况，在图中作出转动方向和受力方向。

Based on the above analysis and force conditions, the rotation direction and force direction are drawn in the figure.

(1) （6 分）蜗轮 2 右旋;齿轮 3 右旋;齿轮 4 左旋。
Worm gear 2 is right-handed; gear 3 is right-handed; gear 4 is left-handed.

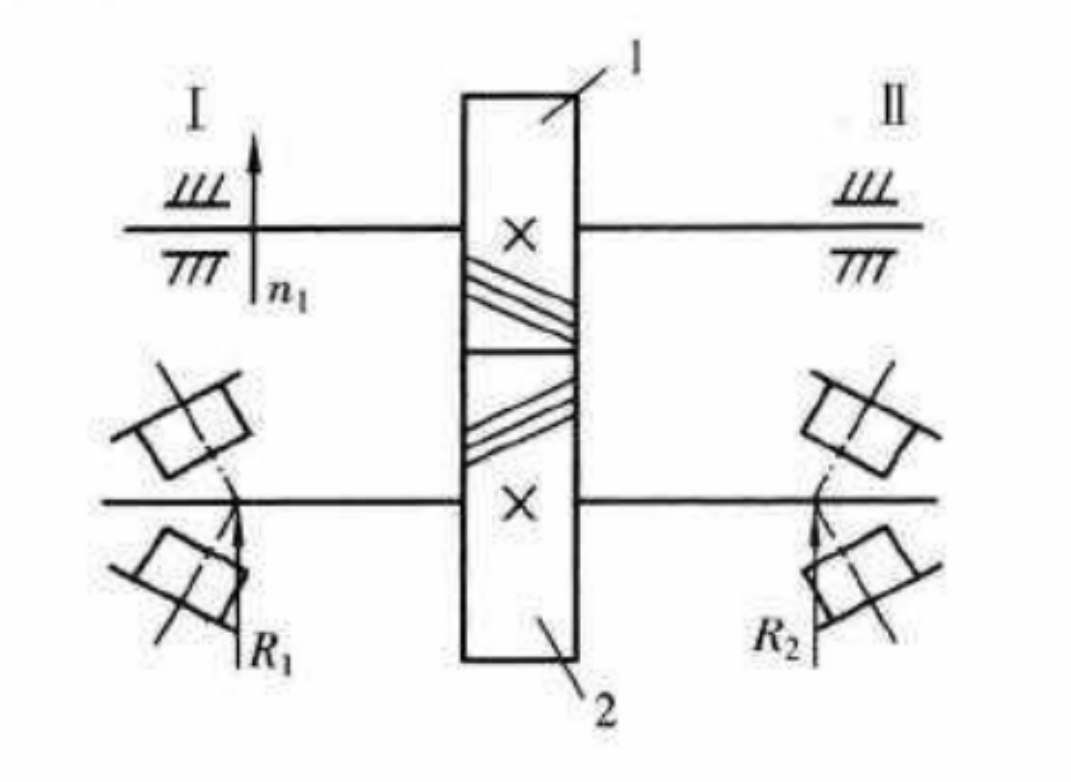
(2) （6 分）如图所示。
As shown in the figure.

(3) （16 分）如图所示。
As shown in the figure.



3、（30 分）如图所示为一对斜齿圆柱齿轮传动。已知：主动小齿轮 1 受的轴向力 FA1=1000N,小齿轮 1 的转向（顺时针）如图所示；从动大齿轮 2 用两个圆锥滚子轴承支承,轴承上受的径向负荷为 R1=7000N，R2=12000N。试求两轴承所受的轴向负荷 A1 与 A2。（S = R/（2Y），Y=1.8）。

3、（30points）As shown in the figure for a pair of helical cylindrical gear transmission. Known: active pinion 1 by the axial force F_{A1} = 1000N, pinion 1 steering as shown in the figure (clockwise); driven gear 2 with two tapered roller bearings, bearings subject to radial load R_1 = 7000N, R_2 = 12000N. Try to find the two bearings subjected to axial load A_1 and A_2. (S = R / (2Y), Y = 1.8)



参考答案：

（1）判断齿轮 2 的轴向力方向：

F_{A2}的大小与 F_{A1}的相同，但方向则相反，指向轴承Ⅱ。

（2）求 S：

$$S_1 = \frac{R_1}{2Y} = \frac{7000}{2 \times 1.8} N = 1944N$$

$$S_2 = \frac{R_2}{2Y} = \frac{12000}{2 \times 1.8} N = 3333N$$

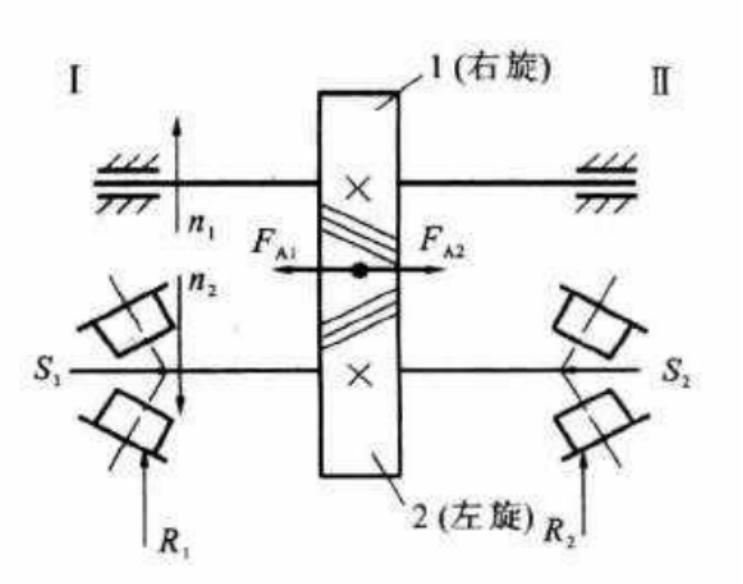
（3）求 A：

$$\text{轴承 I}\begin{cases} A_1 = S_1 = 1944N \\ A_1 = S_2 - F_{A2} = (3333 - 1000)N = 2333N \end{cases}$$

所以 A_1=2333N

$$\text{轴承 II}\begin{cases} A_2 = S_2 = 3333N \\ A_2 = S_2 + F_{A2} = (1944 + 1000)N = 2944N \end{cases}$$

所以 A_2=3333N



Answer:

(1) Determine the direction of the axial force on gear 2:

The magnitude of F_{A2} is the same as that of F_{A1}, but the direction is reversed, pointing towards bearing II.

(2) Request S:

$$S_1 = \frac{R_1}{2Y} = \frac{7000}{2 \times 1.8} N = 1944N$$

$$S_2 = \frac{R_2}{2Y} = \frac{12000}{2 \times 1.8} N = 3333N$$

(3) Request A:

$$\text{轴承 I}\begin{cases} A_1 = S_1 = 1944N \\ A_1 = S_2 - F_{A2} = (3333 - 1000)N = 2333N \end{cases}$$

所以 A_1=2333N

$$\text{轴承 II}\begin{cases} A_2 = S_2 = 3333N \\ A_2 = S_2 + F_{A2} = (1944 + 1000)N = 2944N \end{cases}$$

所以 A_2=3333N

4、（30 分）如图所示，轴上装有一斜齿圆柱轮，齿轮轮齿受到圆周力F_{te}=8100N，径向力F_{re}=3052N，轴向力F_{ae}=2170N，电动机的转速 n=1450r/min，电动机功率 P=10kW，试：

(1) 画出轴的受力简图；

(2) 计算支承反力；

(3) 画出轴的弯矩图、合成弯矩图及转矩图；

(4) 指出危险剖面的位置。

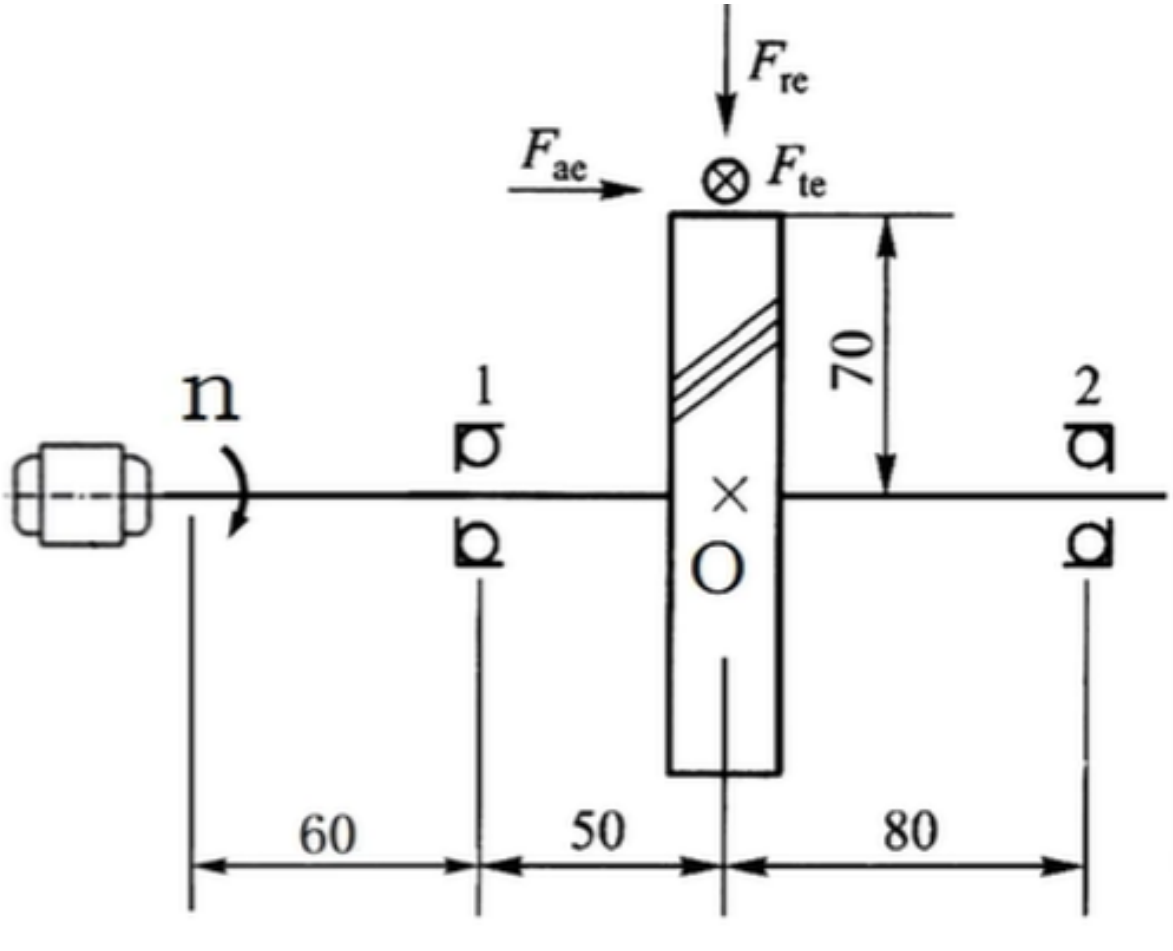
4、（30points）As shown in the figure, a helical cylindrical gear is mounted on the shaft. The gear teeth are subjected to a circumferential force F_{te}=8100N, radial force F_{re}=3052N, axial force F_{ae}=2170N, motor speed n=1450r/min, motor power P=10kW, try to:

(1) Draw the force diagram of the shaft;

(2) Calculate the support reactions;

(3) Draw the bending moment diagram, the resultant bending moment diagram, and the torque diagram for the shaft;

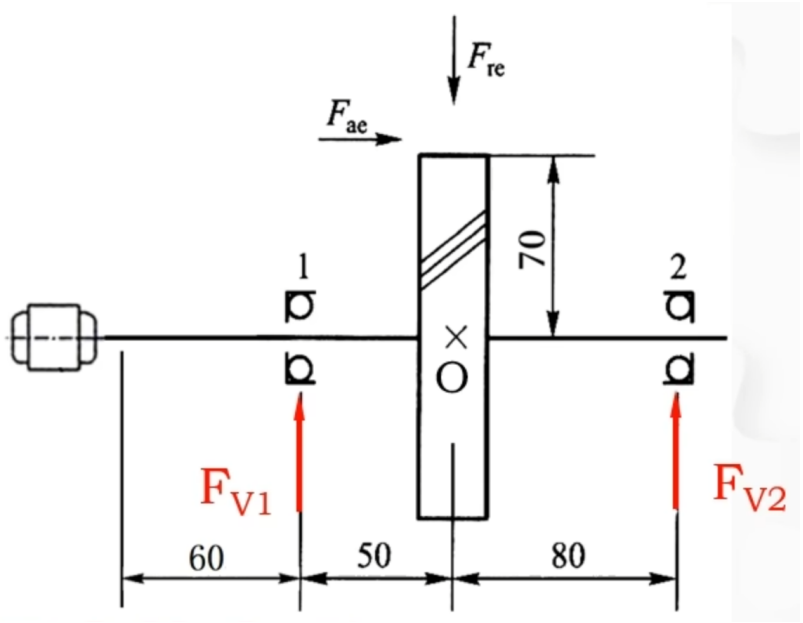
(4) Identify the location of the most dangerous section.



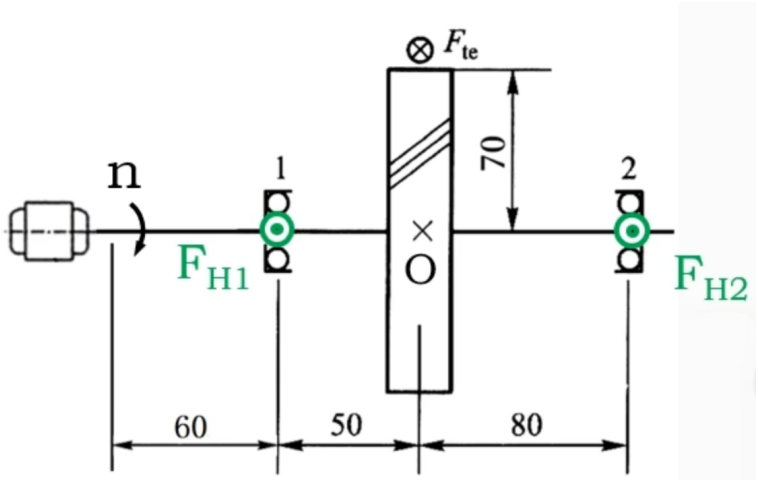
参考答案：

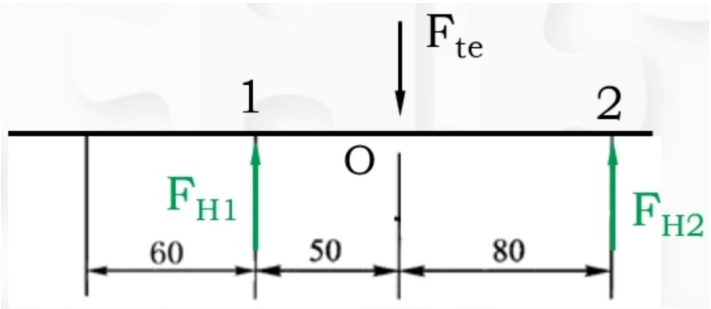
（1）（5 分）

铅锤面：In vertical plane:



水平面：In horizontal plane:





（2）（5 分）

在铅锤面力系，以轴承 2 为支点取转矩：

In vertical plane, take bearing 2 as the pivot to calculate the torque:

$$F_{V1} * (50 + 80) + F_{ae} * 70 - F_{re} * 80 = 0$$

解得：

We get:

$$F_{V1} = \frac{80F_{re} - 70F_{ae}}{50 + 80} = 709.7N$$

$$F_{V2} = F_{re} - F_{V1} = 2342.3N$$

在水平面力系，以轴承 2 为支点取转矩：

In the horizontal plane, take bearing 2 as the pivot to calculate the torque:

$$F_{H1} * (50 + 80) + F_{te} * 80 = 0$$

解得：

We get:

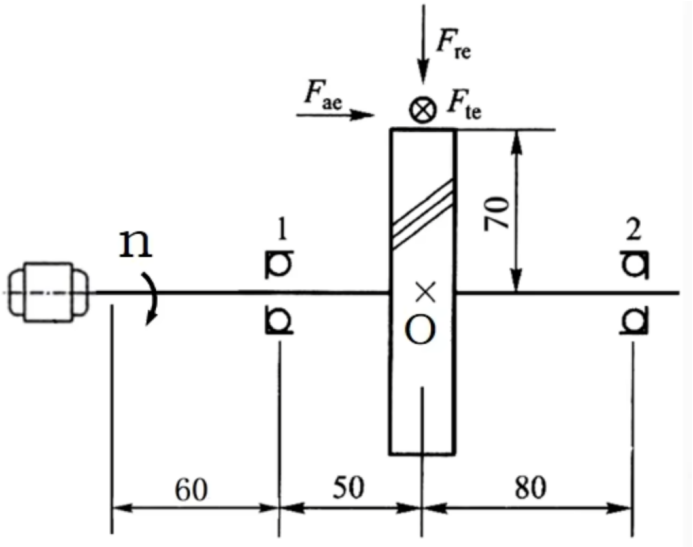
$$F_{H1} = \frac{80F_{te}}{50 + 80} = 4984.6N$$

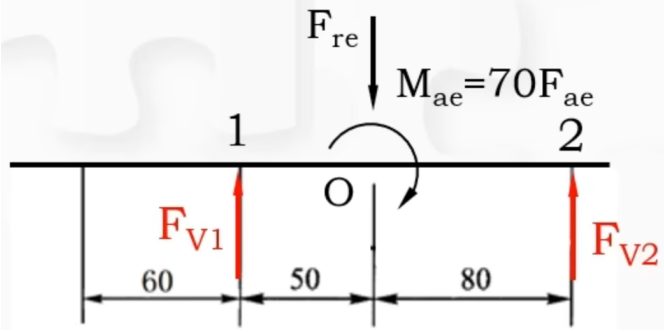
$$F_{H2} = F_{te} - F_{H1} = 3115.4N$$

（3）（5 分）

铅锤面进行分析：

In vertical plane:





对 O 点取矩：

Taking moments about point O:

$$M_{V1} = F_{V1} * 50 = 709.7 * 50 = 35485N * mm = 35.5N * m$$

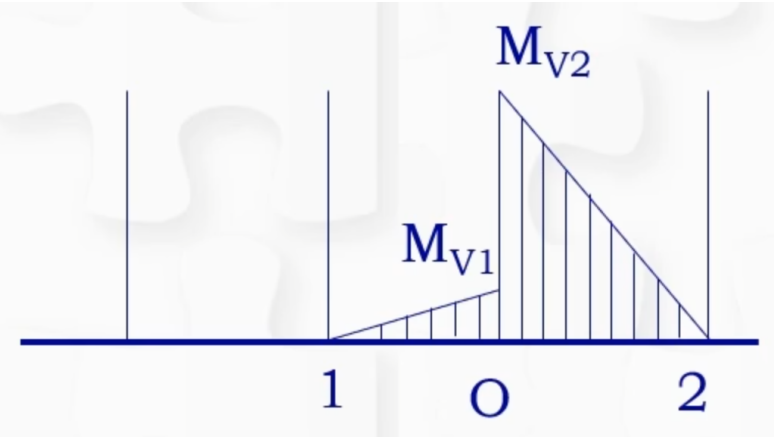
$$M_{V2} = F_{V2} * 80 = 2342.3 * 80 = 187384N * mm = 187.4N * m$$

$$M_{ae} = F_{ae} * 70 = 2170 * 70 = 151900N * mm = 151.9N * m$$

$$M_{ae} = M_{V2} - M_{V1}$$

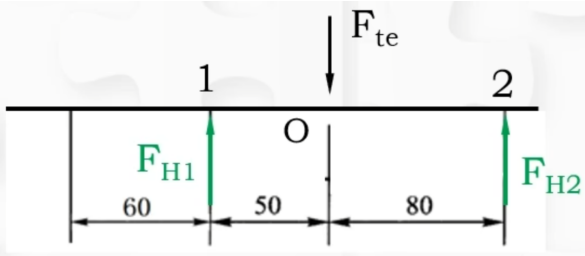
铅锤面弯矩图:

Bending moment diagram in vertical plane:



水平面进行分析：

In horizontal plane:



对 O 点取矩：

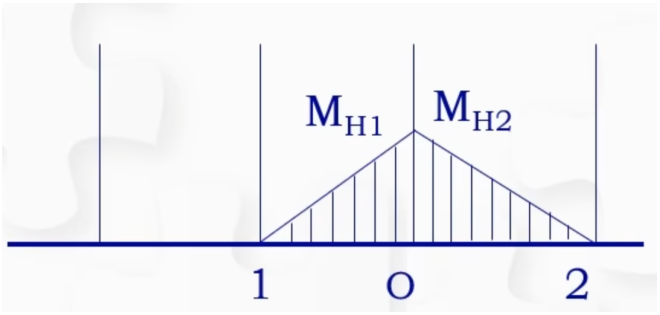
Taking moments about point O:

$$M_{H1} = F_{H1} * 50 = 4984.6 * 50 = 249230N * mm = 249.2N * m$$

$$M_{H2} = F_{H2} * 80 = 3115.4 * 80 = 249232N * mm = 249.2N * m$$

水平面弯矩图:

Bending moment diagram in horizontal plane:

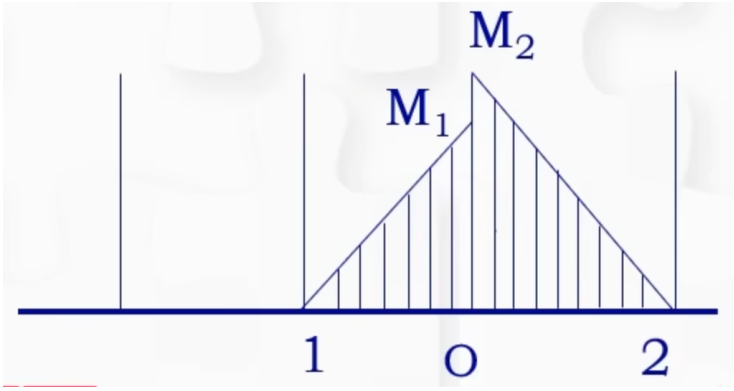


合成弯矩图：

Composite bending moment diagram:

$$M_1 = \sqrt{M_{V1}^2 + M_{H1}^2} = \sqrt{35.5^2 + 249.2^2} = 251.7N * m$$

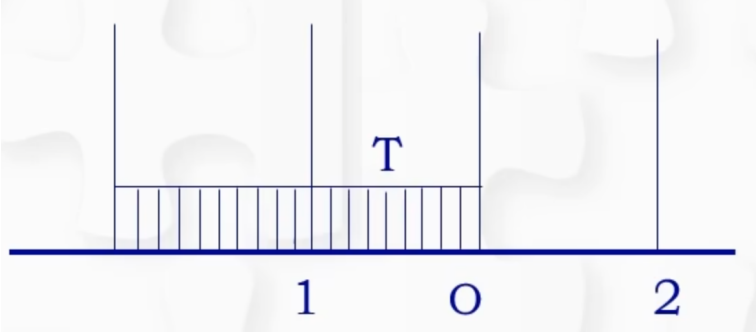
$$M_2 = \sqrt{M_{V2}^2 + M_{H2}^2} = \sqrt{187.4^2 + 249.2^2} = 311.8N * m$$



转矩图：

Torque diagram:

$$T = 9550 * 10^3 \frac{P}{n} = 9550 * 10^3 * \frac{10}{1450} = 65862.1N * mm = 65.9N * m$$



（4）（5 分）

计算当量弯矩：(取$\alpha = 0.6$)

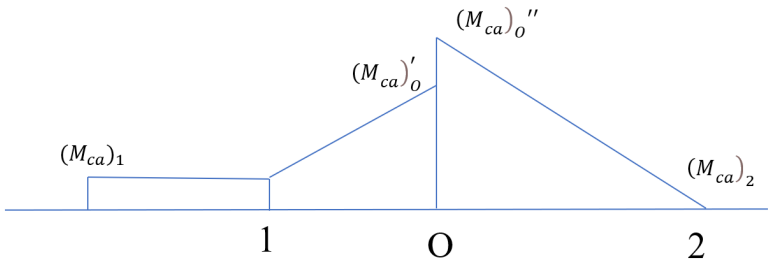
Calculate the equivalent bending moment: (taking $\alpha = 0.6$)

$$(M_{ca})_1 = \sqrt{(\alpha T)^2} = 0.6 * 65.9 = 39.5N * m$$

$$(M_{ca})'_O = \sqrt{{M_1}^2 + (\alpha T)^2} = \sqrt{251.7^2 + (0.6 * 65.9)^2} = 254.8N * m$$

$$(M_{ca})''_O = \sqrt{{M_2}^2 + (\alpha T)^2} = \sqrt{311.8^2 + (0.6 * 0)^2} = 311.8\ N * m$$

$$(M_{ca})_2 = 0N * m$$



O 点截面处.

At the section through point O.