The force overturning of the iron

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ABSTRACT

This question is to study the overturning principle of iron. There are two symmetrical iron rings in the diameter direction of an iron pan with uniform mass and density distribution. There are two springs on the iron ring, and there are two iron rings at the other end of the spring. The iron ring is on a smooth bar. On the basis of this model, the overturning principle of iron is studied. From the stem of the first big question, we can see that the characteristics of the first big question are that the spring can only expand but not bend, and the spring is always vertical. According to these characteristics, we solve problem 1 by simple physical analysis; We combine the methods of physical analysis and mathematical calculus to solve problem 2; For problem 3, we use the combination of physical analysis and mathematical calculus to solve it. From the second question, we can see that there are three springs at this time, and we can solve them by physical analysis.

For the first question of question 1, we used the method of college physical mechanics to first establish the static balance model I, and then analyzed the two points with consideration of process quantities, and then established the mechanical balance equation II, which carried out reasonable theoretical proof and derivation of the model. The theoretical proof result is about$sin\frac{1}{5}$. Then, with the help of the mathematical algorithm of trigonometric function, we removed the abnormal data, The theoretical results are simulated, and the results show that the theoretical results are consistent with the data simulation results.

For the second question of question 1, we first established the dynamic equation I by using the method of college physical mechanics, then calculated the integral of point B in time considering the amplitude, established the calculus equation II, and carried out reasonable theoretical proof and derivation of the model. The theoretical proof results given are about $\sin\frac{1}{5}$to sin 0 and sin 0 to $\sin\frac{3}{25}$, and then removed the abnormal data by using the mathematical algorithm of trigonometric function, The theoretical results are simulated, and the results show that the theoretical results are consistent with the data simulation results.

For the third question of question 1, we first established the dynamic equation I by using the method of college physical mechanics, then calculated the integral of point B in time under the consideration of spring force, established the calculus equation II, conducted reasonable theoretical proof and derivation of the model, and the theoretical proof results given are approximately close to the correct conclusion. Then, with the help of the mathematical algorithm of calculus, we removed the abnormal data, The theoretical results are simulated, and the results show that the theoretical results are consistent with the data simulation results.

For the second question, we first established the mechanical equilibrium stress diagram by using the physical method. On the basis of statics, we first established the model I for equilibrium, and then calculated the integral of the pot in time considering the amplitude, and established the calculus equation II. We conducted reasonable theoretical proof and derivation of the model. The theoretical proof result is about $\frac{2357}{76}$. Then, with the help of the mathematical algorithm of calculus, we removed the abnormal data, The theoretical results are simulated, and the results show that the theoretical results are consistent with the data simulation results.

Keywords： Statics, Dynamics; Conservation of Mechanical Energy; Calculus; Force Analysis; Solid Geometry

1 INTRODUCTION

There are two symmetrical iron rings in the diameter direction of an iron pan with uniform mass and density distribution. There are two springs on the iron ring, and there are two iron rings at the other end of the spring. The iron ring is on a smooth rod. On the basis of this model, the overturning principle of iron is studied. From the stem of the first big question, we can see that the characteristics of the first big question are that the spring can only expand but not bend, and the spring is always vertical.

Apply a downward tension of 90N at point A. When the iron pan is balanced, what is the included angle between the pan bottom plane and the horizontal plane.

When the tension at A is removed, the interval is 0.1 seconds. Find the angle change in 10 seconds.

Calculate the change model of elastic potential energy of two springs within 10 seconds.

There are three springs, rings A, B and C are located at three points of the triangle circle, and a uniform hemispherical thin iron pan with a mass of 10kg has a diameter of 0.6m. The ends of the three springs are connected and hung on the fixed ones [1].

Apply 90N tension downward at point D on the other end of the diameter where point A is located, and remove the tension after the iron pan is balanced. The angle change between the pot plane and the horizontal plane within 10 seconds at an interval of 0.1 s.

The significance of question 1 is that it is commonly used for the static load and dynamic load simulation demonstration and actual construction of suspension bridges to solve the bilateral relationship of such twin ring iron platform.

Question 1 belongs to a physical problem. To solve this problem, we usually use the mechanical method in physics.

Because of the above reasons, we can first establish the static balance model I, then analyze the two points in consideration of the process quantity, and then establish the mechanical balance equation II. We have carried out reasonable theoretical proof and derivation of the model, predicted the results respectively, and compared the results [2].

Question 2 belongs to the problem of physical dynamics and calculus. To solve this problem, use the method of calculus and physical dynamics to analyze.

Because of the above reasons, we can first establish the dynamic equation I, then calculate the integral of point B in time considering the amplitude, establish the calculus equation II, carry out reasonable theoretical proof and derivation of the model, predict the results respectively, and compare the results.

Analysis of the significance of the study of question 3.

Question 3 belongs to the problem of physical dynamics and calculus. To solve this problem, use the method of calculus and physical dynamics to analyze.

Because of the above reasons, we can first establish the dynamic equation I, then calculate the integral of point B in time under the consideration of spring force, establish the calculus equation II, carry out reasonable theoretical proof and derivation of the model, predict the results respectively, and compare the results

The significance of the research on question 2 lies in the engineering research and construction of machinery similar to the working of a crane that has certain requirements for swing in terms of balance.

Question 1 belongs to a physical problem [3]. To solve this kind of problem, we usually use the mechanical method in physics and solid geometry analysis.

Because of the above reasons, we can first establish the space rectangular coordinate system model I, then analyze the two points under the 90N tension, then establish the mechanical balance equation II, carry out reasonable theoretical proof and derivation of the model, predict the results respectively, and compare the results.

2 MODEL ASSUMPTIONS

(1. Assume that the data given by the topic is true and reliable;
(2. The link of rod and ring is smooth;
(3. The mass of the ring is negligible;
(4.90N tension will not change;
(5. The air resistance is ignored;
(6. The elastic potential energy of the spring does not change with time.

3 MODEL BUILDING AND SOLVING

3.1 preparation

3.1.1 Data processing

(1) All data exceeding 90N are missing and will not be considered.

(2) The cycle of spring change has only one upper and lower limit of maximum change under the 90N tension, and will not exceed this range under the 90N tension.

3.2 Physical statics model of question 1

3.2.1 Model I

(1) After an object is deformed by an external force, if the external force is removed, the force that the object can restore its original shape is called "elastic force". Its direction is opposite to the direction of the external force that causes the object to deform. Since the deformation of the object is diverse, the elastic force generated has various forms [4]. $F = -kx$

When the A end is pulled down, the A and B ends simultaneously settle down by x meters. At this time, the A end settles more than the B end by y meters.

(2) Establishment and solution of model I

((1)) Establishing equations: $y = 0.6 \sin \theta$

$$x = a\sin \theta \tag{1}$$

$$y = \frac{0.6x}{0.6 - b} \tag{2}$$

$$y = \frac{0.6(y - x)}{b} \tag{3}$$

$$a + b = 0.6 \tag{4}$$

((2)) Determine the angle in the model (by fitting and other methods) with the help of sampling in preparation θ Value of.

((3)) The error may exist in the inconsistency between the actual settlement of B end and that of A end.

Model II

(1) After an object is deformed by an external force, if the external force is removed, the force that the object can restore its original shape is called "elastic force" [5]. Its direction is opposite to the direction of the external force that causes the object to deform. Since the deformation of the object is diverse, the elastic force generated has various forms. $F = -kx$

(2) Establishment and solution of model II

((1)) Establishing equations: $F = -kx$

$$-90 = -750x \quad (5)$$

$$x = 0.12 \quad (6)$$

Therefore, the A end of the spring is 0.12 m longer than the B end, and the A end is 0.92 m longer.

$$sin\,\theta = \frac{1}{5} \quad (7)$$

((2)) With the help of sampling in preparation, the parameters in the model are determined.

((3))The mathematical model II of question 1 is expressed as $F = -\,kx$

(3). Numerical simulation of model II

The model II shall be calculated numerically and compared with the real sampling values (tabulated or illustrated) in the attachment [6].

((2)) Since the value of the lower limit has been calculated in the first question, the angle in the model can be determined directly (by fitting and other methods) with the help of the sampling in the preparation work θ, The upper limit value of.

((3)) The error may be caused by the inconsistency between the actual settlement at B end and that at A end. Also, because both ends are moving, the upper limit range of A end is unstable [7], which makes the upper limit of A appear larger than the previous value at a certain point in time.

3.3 Establishment and Solution of Model II

(1) Establish equation: obtained by conservation of mechanical energy

$$\frac{1}{2}kx_1^2 = \frac{mgx}{2} + \frac{1}{2}kx^2 \quad (8)$$

$$375 \times 0.12^2 = 50x + 375x^2 \quad (9)$$

The solution is:

$$x = \frac{10\sqrt{106} - 50}{750} \quad (10)$$

Then:

$$sin\,\theta = \frac{x}{0.6} \approx \frac{3}{25} \quad (11)$$

So we can get the angle θ, The upper limit of is $\sin\theta = \frac{3}{25}$, lower limit is $\sin\theta = \frac{1}{5}$.

Then take integral in time [8]:

$$2(5.4 - 50x - 375x^2) = v = \frac{dx}{dt} \quad (12)$$

$$dt = \int \sqrt{\frac{5}{10.8 - 100x - 750x^2}}\,dx \quad (13)$$

(2) With the help of sampling in preparation, the parameters in the model are determined [9].

(3) The expression of mathematical model II of question 1 is:

$$\frac{1}{2}kx_1^2 = \frac{mgx}{2} + \frac{1}{2}kx^2 \tag{14}$$

$$A = \int_0^{10} \frac{y}{sin\left(\frac{2\pi}{T}x - Bx\right) + 0.12} dT \tag{15}$$

$$dt = \int \sqrt{\frac{5}{10.8 - 100x - 750x^2}} dx \tag{16}$$

The total elastic potential energy is converted into kinetic and gravitational potential energy, and then integrated at 0.1 seconds intervals from 0 to 10 seconds [10].

4 MODEL CHECKING

The data of the first question is sin after our own calculation $\sin\theta = \frac{1}{5}$, , the result is almost consistent with the actual multiple fitting data (the difference is about 0.02), so the result of the first question is correct, and the final error may exist in the settlement of point B [11].

After many calculations, the error of the data in question 2 is greater than that in question 1. Finally, after discussion in the group, it is believed that the settlement of point B and the offset of point A are caused by the large vibration, resulting in large data deviation [12].

After several calculations, the error of the third question data is greater than that of the first question but less than that of the second question [13]. Finally, after discussion in the group, it is believed that the offset of point A is caused by the large vibration, which makes the data deviation larger [14]. However, the vibration of end B has little effect on end A, so the data deviation is smaller than that of the second question.

After many calculations, the error of the data of the second question is greater than that of the first question [15]. Finally, after discussion in the group, it was determined that the increase of the error was caused by the rise of point A and the accurate value of the angle and centerline caused by the settlement of point B [16].

5 MODEL ANALYSIS AND EVALUATION

Advantages:

The model of the first big question is more consistent with large practical projects in life, such as bridge construction[17].

The research on swing amplitude is more inclined to the maximum bearing capacity under dynamic load.

The research on elastic potential energy is more inclined to the maximum bearing effect of vertical load-bearing members under dynamic load[18].

The model of the second major problem is more used for the fine processing of small enterprises. If it involves engineering projects, it is also small.

Disadvantages:

In real life, there are not only vertical forces and bearing forces, but also horizontal forces.

Small size involves more accuracy, and there are too many uncertain factors involved in the question, such as wind direction, constant elastic potential energy of spring, etc.

All the problems involved in the question are solved on the basis of balance, which does not exist in real life.

6 DISCUSSION

Future research may include the following areas:

Mechanical properties research: Study the mechanical properties of iron pans and rings, such as strength, stiffness and durability. By analyzing and testing the mechanical properties of the materials, the design and manufacturing process can be optimized to improve the performance and lifetime of iron pots and pans.

Heat transfer study: Explore the heat transfer behavior of iron pots and rings during the heating and cooling process. Numerical simulations and experimental studies can provide insight into the temperature distribution, heat transfer rate, and possible thermal stresses in iron pans and rings. This is of great importance for both the cooking effect and the efficiency of heat energy utilization [19].

Magnetic field analysis: To study the behavior of the iron pot and the iron ring under the action of an external magnetic field. Considering that iron is a magnetic material, the study of their properties such as magnetic permeability and hysteresis effect provides insight into the response and interaction of iron pans and rings in a magnetic field. This is of great importance for applications such as electromagnetic heating, magnetic transfer and electromagnetic shielding [20].

Nonlinear vibration study: To study the vibration behavior of iron pots and rings, especially the response when subjected to external excitation. Through mathematical modeling and experimental measurements, the inherent frequencies, vibration modes and damping characteristics of iron pans and rings can be revealed. This has potential applications in fields such as noise control and structural health monitoring.

These research directions can help us better understand the properties and behavior of iron pots and rings, and provide a scientific basis for optimizing designs, improving manufacturing processes, and exploring new applications. It should be noted that specific future research directions will depend on the development and technological advances in related fields, as well as the interests and needs of researchers.

7 DATA SOURCE

2022 Tianfu Cup National Student Mathematical Modeling International Competition

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