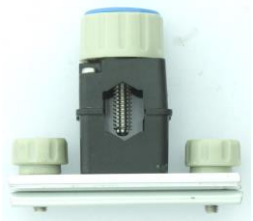
A01-100S-Y05

Mechanics Demonstration Kit (E)

Index

二、Instrument

No.	Accessory	Qty	No.	Accessory	Qty
1	Aluminum base	1	2	Aluminum support stand	1
3	Movable connector	1	4	Iron rod (L400mm)	1
5	Movable hook	2	6	Single pulley	2
7	Mass 20g×10、10g×2	10	8	Rope	1
9	Fixed pulley with track	1	10	Spring balance 250g/2.5N	1
11	Double pulley	2	12	Magnetic movable connector	3
13	Lever balance scale	1	14	Plumb scale chart with connector	1
15	Iron hook	1	16	Weight dish	2
17	S-hook	7	18	Axle (Includes iron rod)	1
19	Angle disk	1	20	Inclined table	1
21	Fix pulley on an inclined table	1	22	Cart	1
23	Mass with hole (100g)	2	24	O-ring	1
25	Spring (for Hook's law)	1	26	Friction plane	1
27	Wood block (for friction)	1	28	Mass 100g (for friction)	2
29	Vertical quadrilateral plate	1			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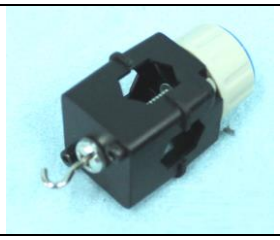			
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			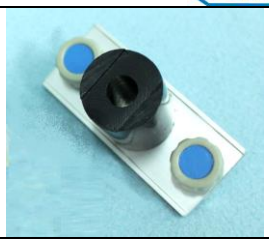
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	 		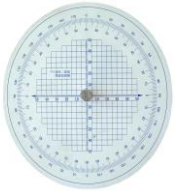
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			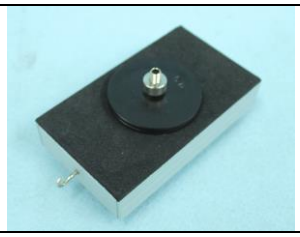
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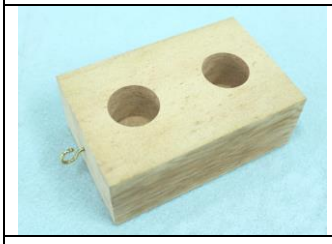		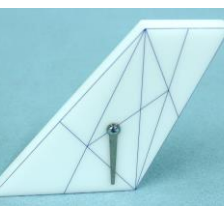	
27	**28**	**29**	

Experiment I. Fixed pulley

Purpose

1. Learn principles of fixed pulleys.
2. Features of fixed pulley: Neither labor saving nor effortless/ changing the direction of force.

Instruments

No.	Accessory	Qty	No.	Accessory	Qty
1	Aluminum base	1	2	Aluminum bracket	1
3	Movable connector	1	4	Iron rod 10 mm x 400 mm	1
5	Movable hook	2	6	Single pulley	2
7	Weight 20g*10、10g*2	12	8	Rope	1

Theory

1. **Pulley:** A pulley is a wheel with groove at the edge over which a rope is pulled to lift heavy things. If the axle of the wheel is fixed, it is a **fixed pulley**. If the axel is movable, it is a **movable pulley**. The mechanical function of a pulley is similar to a lever.

2. **Fixed pulley:** As shown in **Figure 1**, the effort and the resistance are at the opposite sides of the fulcrum. Despite the angle of effort, the effort arm is perpendicular to the effort and the resistance arm is perpendicular to the resistance, as shown in **Figure 2**. Thus, regardless the angles of effort and resistance, the arms of effort and resistance remain equal. We can conclude that a fixed pulley does not save labor but it can change the direction of applied force.

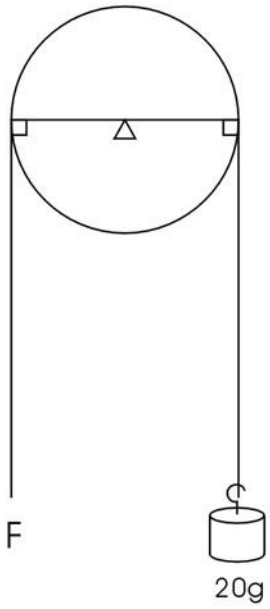

Figure 1

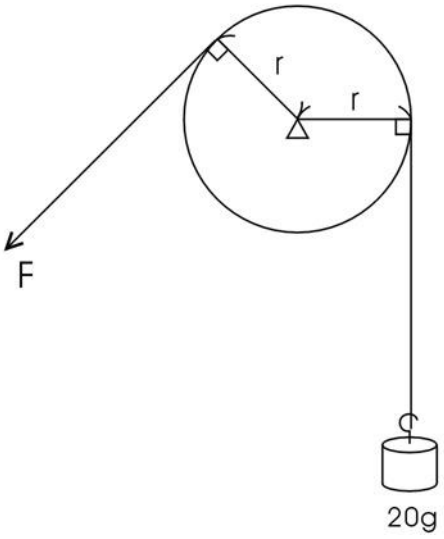

Figure 2

Procedure

1. The experimental setup is shown in **Figure 3**.

2. Hang weight (20g) on the left rope and hang several weights on the right rope.

3. Observe when will the lever reaches equilibrium.

4. Record reading on the spring balance.

5. Change the weight into 40 g, 60 g, 80 g and 100 g. Record their results.

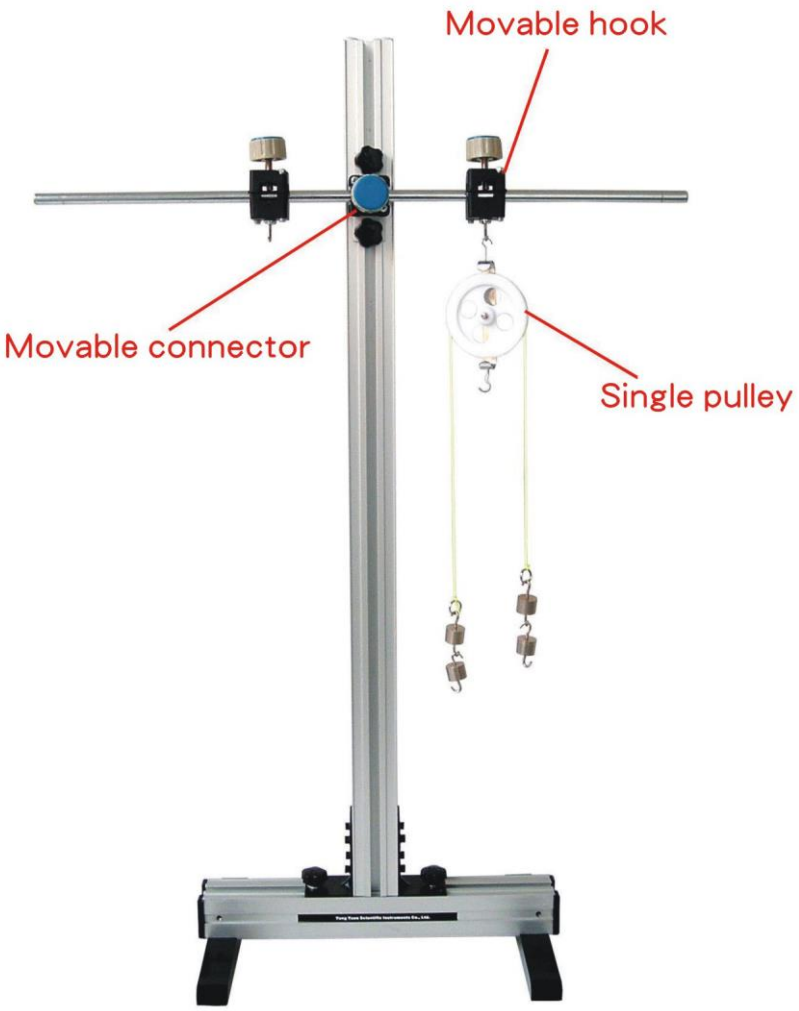

Figure 3

Experiment result and discussions

Weight on the left	Weight on the right
g	g
g	g
g	g
g	g

1. If we pull down one of the ropes when the lever reaches equilibrium, what will happen?

Experiment II. Movable Pulley - Single

Purpose

1. Learn principles of a movable pulley.
2. Features of a movable pulley- labor saving but time consuming.

Instruments

No.	Accessory	Qty	No.	Accessory	Qty
1	Aluminum base	1	2	Aluminum bracket	1
3	Movable connector	1	4	Iron rod 10 mm x 400 mm	1
5	Movable hook	2	6	Single pulley	2
7	Weight 20g*10、10g*2	12	8	Rope	1
9	Fixed pulley	1	10	Spring balance 250g/2.5N	1

Theory

1. 1. Pulley: A pulley is a wheel with groove at the edge over which a rope is pulled to lift heavy things. If the axle of the wheel is fixed, it is a **fixed pulley**. If the axel is movable, it is a **movable pulley**. The mechanical function of a pulley is similar to a lever.
2. 2. **Pulley:** As shown in **Figure 4**, the effort is at the edge of axle and the resistance is at the center of wheel. When F pulls, the edge of wheel (triangle part) is the fulcrum. The effort arm is the diameter and the resistance arm is the radius. In other words, the effort arm is twice longer than the resistance arm. A balanced torque only requires the effort to be half the resistance. Thus, if we want to lift a 20g weight, without considering the weight of pulley, we at least need 10gw force.

   Without considering the friction of rope, the work of upward perpendicular force is $W = F \times \Delta X = (\frac{1}{2}mg)\Delta X$. The potential energy the object acquires is $\Delta U = mg\Delta Y$ (ΔY is the distance the movable pulley moves). Based on the kinetic energy theorem, the work of upward perpendicular force W equals to the potential energy ΔU the object acquires.

   Thus, $(\frac{1}{2}mg)\Delta X = mg\Delta Y$ so $\Delta Y = \Delta X / 2$

   As shown in **Figure 5**, when the effort moves ΔX, the movable pulley only moves $\Delta X / 2$.

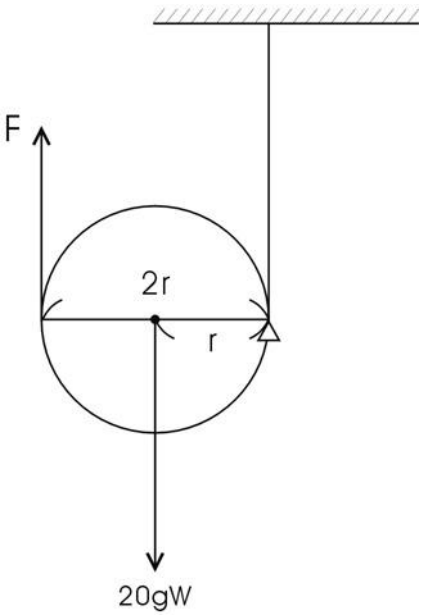

Figure 4

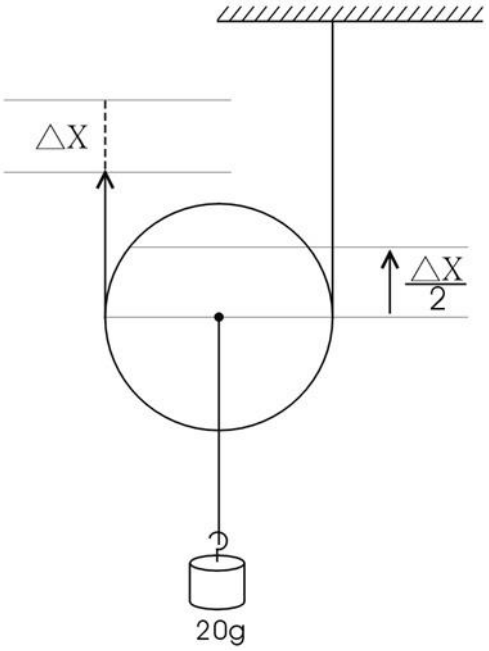

Figure 5

Procedure

1. The experimental setup is shown in **Figure 6**.

2. Record the reading on the spring balance after hanging a 20g weight on the left rope.

3. Change the weight into 40 g, 60 g, 80 g and 100 g and repeat above procedure. Record experiment results.

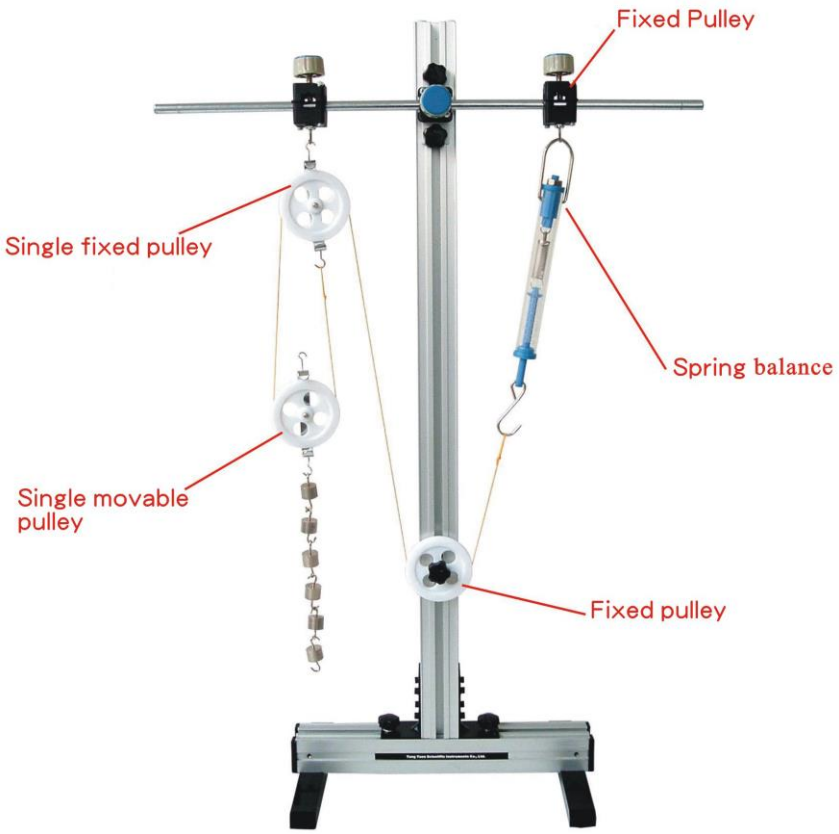

Figure 6

Experiment result and discussions

Weight	Reading on spring balance
Pulley 28.5 gw	
Hanger 25gw	
Add 10 g weight	
Add 20 g weight	
Add 30 g weight	

1. What are possible causes of experimental errors?

2. If the direction of the pulling force is not upward perpendicular, will we get different results?

Experiment III. Movable Pulley - Double

Purpose

Learn principles and features of a double pulley.

Instruments

No.	Accessory	Qty	No.	Accessory	Qty
1	Aluminum base	1	2	Aluminum bracket	1
3	Movable connector	1	4	Iron rod10 mm x 400 mm	1
5	Movable hook	2	7	Weight 20g*10、10g*2	12
8	Rope	1	9	Fixed pulley	1
10	Spring balance 250g/2.5N	1	11	Double pulley	2

Theory

1. **Set of single and double pulleys:** As shown in **Figure 7**, fix the single pulley on the wall to become a fixed pulley. Circle ropes around pulleys. Based on features of movable pulleys, the effort of this pulley set is a quarter of the resistance so the function of this pulley set equals to the pulley set in **Figure 8**. The design on **Figure 7** can lift the object to the highest place. On the design of **Figure 8**, when pulley a is at the highest position, pulley B can only reaches half of the height.

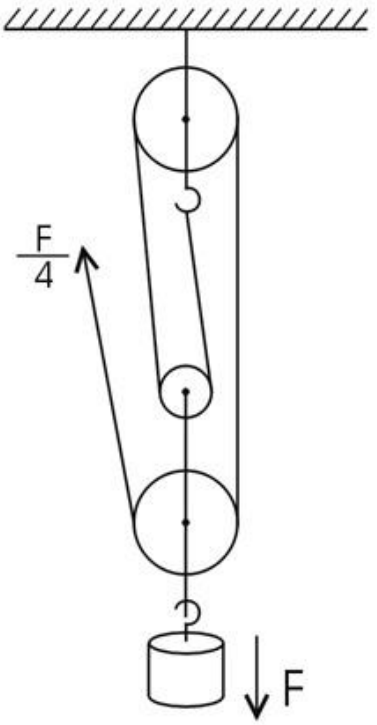

Figure 7

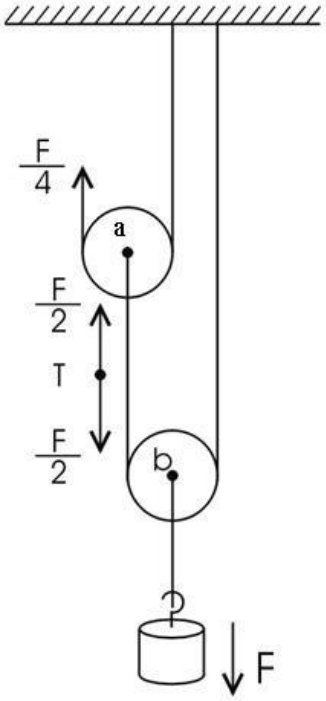

Figure 8

2. Set of two double pulleys: As shown in **Figure 9**, fix a double pulley on the wall to become a fixed double pulley. The structure of the set is similar to **Figure 7** but with one extra fixed pulley to change the direction of applied force.

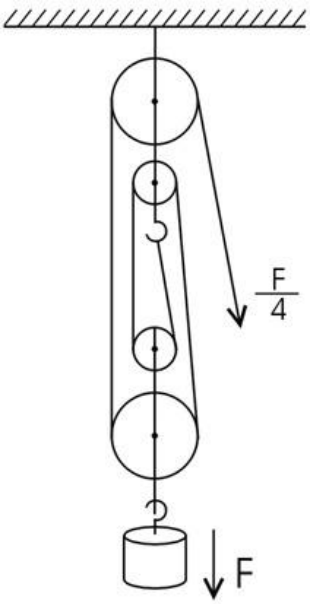

Figure 9

Procedure

1. The experimental setup is shown in **Figure 10**.

2. Hang a 20g weight on the double pulley and record the reading. The weight of double pulley is 38.5g and the holder is 25g.

3. Change the weight into 40 g, 60 g, 80 g and 100 g. Record readings on the spring balance.

4. Observe whether the pulling force of this system is a quarter of the object's weight.

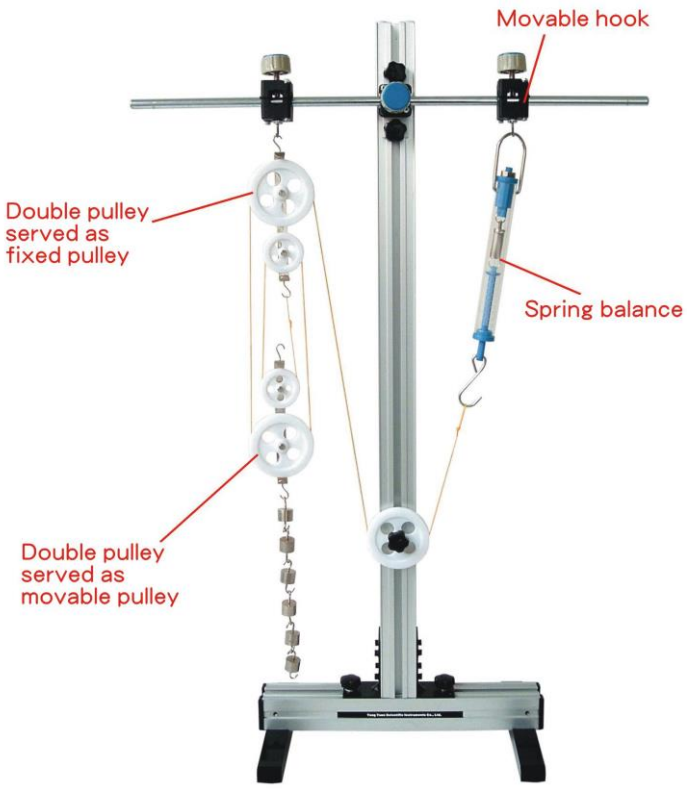

Figure 10

Experiment results and discussions

Object's weight	Reading on spring balance

1. What are possible causes of experimental errors?

2. If we want to pull an object which is eightfold heavier than the applied force, how should we design the pulley set?

Experiment IV. First-type Lever

Purpose

Learn principles and features of first-type lever.

Instruments

No.	Accessory	Qty	No.	Accessory	Qty
1	Aluminum base	1	2	Aluminum bracket	1
3	Movable connector	1	7	Weight 20g*10、10g*2	12
12	Movable magnetic connector	3	13	Lever balance scale	1
14	Leveling rod	1	15	Hook stick	1