

## Fixed pulley, loose pulley and block and tackle as simple machines on the adhesive magnetic board

### Objects of the experiment

- Measuring the tensile force at a block and tackle as a function of the gravitational force of the suspended load.
- Measuring the tensile force at constant load in dependence on the number of pulleys in the block and tackle.

### Principles

Fixed pulley, loose pulley and block and tackle are classic examples of a simple machine. They are also called force converters as they change the point of action, the direction or the magnitude of the force  $F$  which is required, e.g., for lifting a load of weight  $G$  (see Fig. 1).

If a rope is laid around a fixed pulley, the load can be pulled upwards with a force

$$F = G \quad (I),$$

which is directed downwards.

If a loose pulley is employed, the gravitational force  $G$  is equally distributed on both ends of the rope around the pulley so that the force required for lifting the load is halved. By a combination of a loose and a fixed pulley it is possible to lift the load with the force

$$F = \frac{G}{2} \quad (II),$$

which is directed downwards.

In the case of a block and tackle, this result is consistently extended. If two pairs of a fixed and a loose pulley are used in a block and tackle, the gravitational force  $G$  is equally distributed on four parts of the rope. Since the tensile stress is the same at every position of the rope, the tensile force to be applied at the end of the rope is

$$F = \frac{G}{4} \quad (III).$$

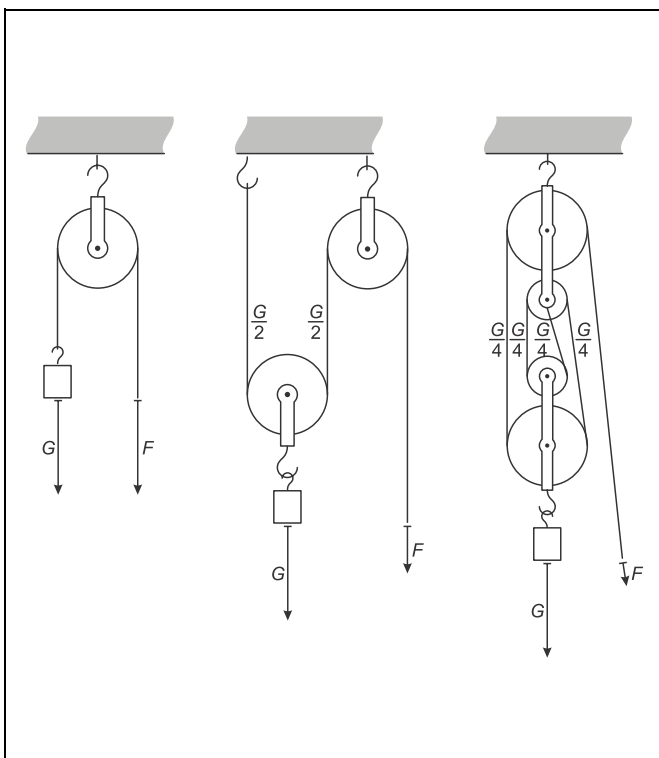


Fig. 1 fixed pulley (left), loose pulley (middle) and block and tackle (right)

**Apparatus**

1 adhesive magnetic board . . . . .	301 301
2 pulleys, plug-in, 50 mm diameter . . . . .	340 911
2 pulleys, plug-in, 100 mm diameter . . . . .	340 921
2 pulley bridges . . . . .	340 930
2 load hooks . . . . .	340 87
1 magnetic base with 4-mm socket . . . . .	301 330
1 magnetic base with 4-mm axis . . . . .	301 332
1 magnetic base with hook . . . . .	301 331
1 round dynamometer 2 N . . . . .	314 212
1 round dynamometer 5 N . . . . .	314 215
1 set of 12 weights, 50 g each . . . . .	342 61
1 demonstration cord, 20 m (polyamide) . . . . .	309 50
1 demonstration-experiment-frame . . . . .	301 300
or	
4 Leybold multiclips . . . . .	301 01
4 metal plates . . . . .	200 65 559
2 stand rods, 100 cm . . . . .	300 44
2 simple bench clamps . . . . .	301 07

**Setup**

- Set up the adhesive magnetic board according to the instruction sheet with the demonstration-experiment-frame or with stand material.

**Carrying out the experiment**

**a) Gravitational force:**

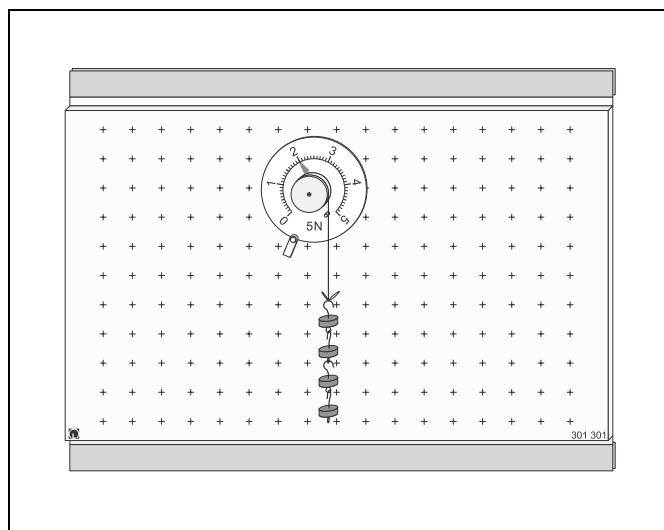


Fig. 2 Determining the gravitational force

- Attach the round dynamometer to the adhesive magnetic board, and make the zero adjustment.
- One after another suspend two, four, six and eight weights so that the thread leaves the round dynamometer tangentially. Each time read the gravitational force  $G$ .

**b) Fixed pulley:**

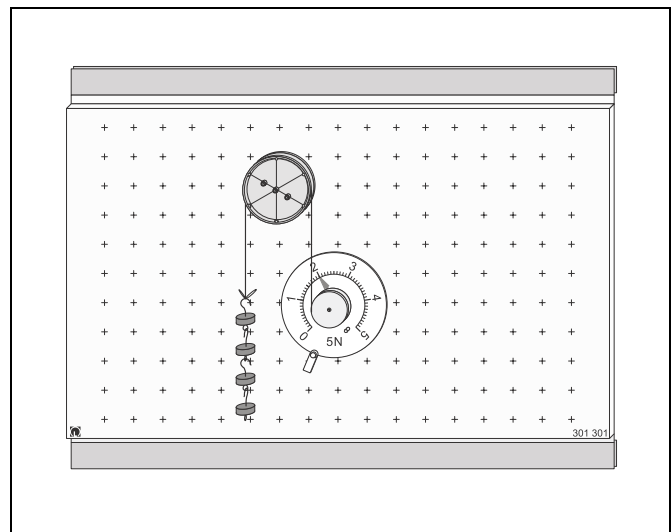


Fig. 3 Experimental setup with fixed pulley

- In addition, attach the magnetic base with 4-mm socket and put a large pulley on it.
- Lay the demonstration cord starting from the round dynamometer around the pulley.
- See to it that the thread leaves the round dynamometer tangentially.
- Adjust the zero of the round dynamometer.
- One after another suspend two, four, six and eight weights from the demonstration cord, and read the force  $F$  that acts on the round dynamometer.

**c) Fixed and loose pulley:**

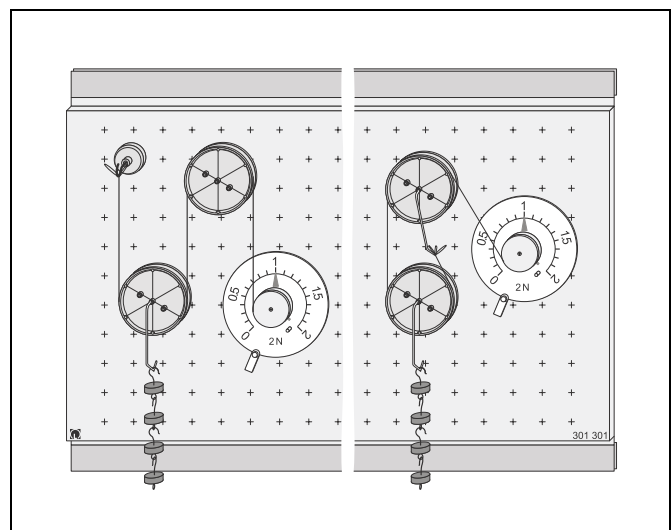


Fig. 4 Experimental setup with fixed and loose pulley

- Replace the round dynamometer 5 N with the round dynamometer 2 N.

*Version 1:*

- In addition, attach the magnetic base with hook.
- Equip the second large pulley with a load hook.

- Lay the demonstration cord – as shown on the left of Fig. 4 – starting from the hook around the loose and the fixed pulley to the round dynamometer.
- See to it that the thread leaves the round dynamometer tangentially.
- Adjust the zero of the round dynamometer.
- One after another suspend two, four, six and eight weights from the loose pulley, and read the force  $F$  that acts on the round dynamometer.

Version 2:

- Equip the first pulley with a load hook as well, and attach the demonstration cord to it with a loop (see right-hand side of Fig. 4).
- Repeat the measurements.

d) Block and tackle

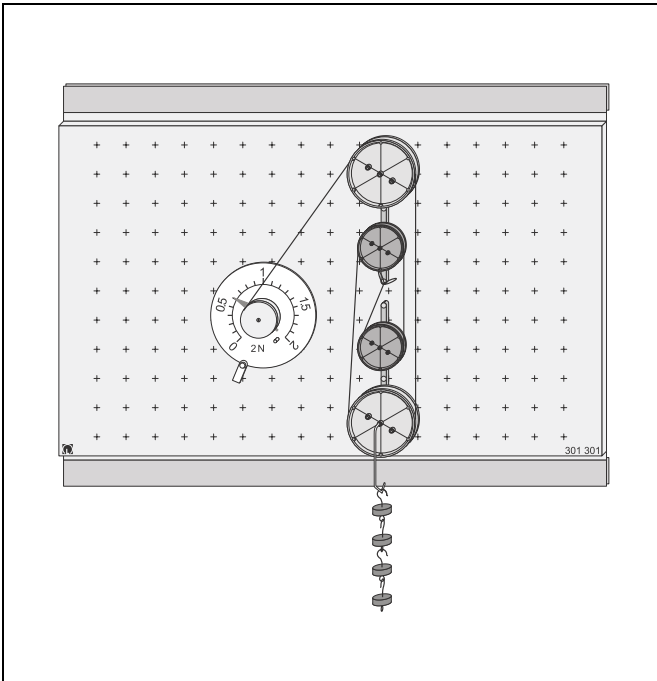


Fig. 5 Experimental setup with block and tackle

- Put a small and a large pulley each on the two pulley bridges.
- Attach the magnetic base with 4-mm axis and suspend a pulley bridge from it so that the small pulley points downwards; fix the pulley hook to the small pulley.
- Lay the demonstration cord – as shown in Fig. 5 – starting from the round dynamometer around all four pulleys.
- Suspend the second pulley hook from the lower large pulley.
- See to it that the thread leaves the round dynamometer tangentially.
- Adjust the zero of the round dynamometer.
- One after another suspend two, four, six and eight weights from the block and tackle, and read the force  $F$  that acts on the round dynamometer.

Measuring example

		fixed pulley	loose pulley	block and tackle
$\frac{m}{g}$	$\frac{G}{N}$	$\frac{F}{N}$	$\frac{F}{N}$	$\frac{F}{N}$
100	1	1	0.5	0.25
200	2	2	1	0.5
300	3	3	1.5	0.75

Evaluation and results:

The force  $F$  required for lifting a mass  $m$  is equal to the gravitational force  $G$  in the case of a fixed pulley, half the gravitational force in the case of a loose pulley and a quarter of the gravitational force in the case of a block and tackle with four pulleys.

