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Experimental verification of Newton's Second Law, ΣF = Ma.

Equipment:

A wooden Planck with scale and frictionless surface, trolley of known weight. Cotton threads, stop watch, and slotted weights

Theory:

Newton's 2nd law simply states that

"A nonzero net force ΣF acting on mass M generates an acceleration a in that mass such that ΣF = Ma."

In Fig. 1, assuming no friction, the hanging mass m can cause motion for both m and M**.** The force of gravity on m is F = mg**.** This force has to move a total mass of m + M**.** In the absence of friction, F = mg is the **only force** causing motion**.** In this case mg is the ΣF.

Using Newton's 2nd Law:

ΣF = (Mass)(Accel.) , we may write**:**

mg = (m + M) a or,

a = mg / (m + M).

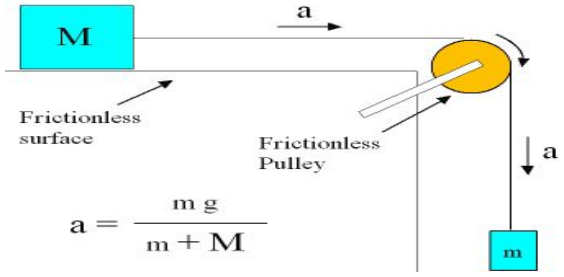

Fig. 1

Using Newton's 2nd Law:

ΣF = (Mass)(Accel.), we may write**:**

mg - μ Mg = (m + M) a or,

a = (mg - μ Mg) / (m + M).

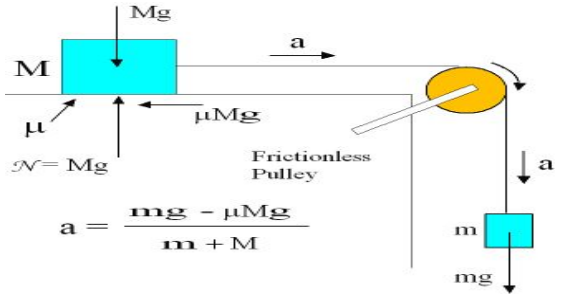

Fig. 2

In Fig. 2, assume friction is present for M only because it has to slide on the top of the horizontal table**.** Since N = w in magnitude for M, we may write or N = Mg**.**

 Signature:

The force of kinetic friction is $F_k = \mu N$, or $F_k = \mu Mg$.

Procedure:

1. Fix the trolley on one side of wooden Planck and note its position by scale provided on it.
2. Tied the hook of Planck with thread and pass over pulley and tied the slotted weight.
3. When the Planck moves due to weight start stop watch and when it moves other end of Planck stop the stop watch.
4. Note the time taken by wooden trolley to move.

OBSERVATION TABLE

Given and Measured $g = 9.81\ m/s^2$**.** S = length of the wooden bench

S.NO	m (g)	M (g)	μ_k	Time (t) (ms)	Distance (cm)	$\Sigma F=mg - \mu M$ (N)	Total mass M + m (g)	Measured a = $\Sigma F/(M+m)$ (m/s^2)	Calculated a =$2S/t^2$ (m/s^2)
1.	10	20	0.002	78	100	0.0977	30	3.2567	3.2873
2.	15	10	0.003	58	100	0.1468	25	5.8720	5.9453
3.	5	30	0.002	120	100	0.0485	35	1.3857	1.3889
4.	30	30	0.004	64	100	0.2931	60	4.8850	4.8828
5.	40	50	0.004	68	100	0.3904	90	4.3378	4.3252

Calculation(s):

$$\Sigma F = mg - \mu Mg$$
$$= g(m - \mu M)$$

F1=9.81x((10 - 20 x 0.002) x10^(-3))
= 0.0977 N
F2 = 9.81x((15 - 10 x 0.003) x10^(-3))
= 0.1468 N
F3 = 9.81x((5 - 30 x 0.002) x10^(-3))
= 0.0485 N
F4 = 9.81x((30 - 30 x 0.004) x10^(-3))
= 0.2931N
F5 = 9.81x((40 - 50 x 0.004) x10^(-3))
= 0.3904 N

Measured a = ΣF/(M+m)

Measured a1 = 0.0977 /(30x10^(-3))
= 3.2567 m/s^2
Measured a2 = 0.1468 /(25x10^(-3))
=5.8720 m/s^2
Measured a3 = 0.0485/(35x10^(-3))
=1.3857 m/s^2
Measured a4 = 0.2931/(60x10^(-3))
= 4.8850 m/s^2
Measured a5 = 0.3904/(90x10^(-3))
=4.3378 m/s^2

Calculated a =2S /t²

Calculated a1 = 2x(100 x10^(-2))/(0.78x0.78)
= 3.2873 m/s²
Calculated a2 = 2x(100 x10^(-2))/(0.58x0.58)
= 5.9453 m/s²
Calculated a3 = 2x(100 x10^(-2))/(1.2x1.2)
= 1.3889 m/s²
Calculated a4 = 2x(100 x10^(-2))/(0.64x0.64)
= 4.8828 m/s²
Calculated a5 = 2x(100 x10^(-2))/(0.68x0.68)
= 4.3252 m/s²

Error calculation.

Error = |measured a – calculated a|/calculated x 100

E1 = |3.2567 - 3.2873|/3.2873 x 100

=0.9308%

E2 = |5.8720 - 5.9453|/5.9453 x 100

= 1.2329%

E3 = | 1.3857 - 1.3889|/1.3889 x 100

= 0.2304%

E4 = |4.8850 - 4.8828|/ 4.8828 x 100 = 0.04506%

E5 = |4.3378 - 4.3252|/4.3252 x 100

=0.2913%

Average error =0.9308+1.2329+0.2304+ 0.04506+0.2913/**5**

= **0.5461%**

Conclusion:

The calculated and the measured acceleration values are almost equal with an error of **0.5461%.**

Hence it verifies the **NEWTON'S SECOND LAW OF MOTION**

Precaution.

1. The pulley should be frictionless.
2. There shouldn't be any twist in the string.
3. Mass of pulley should be negligible.
4. Surface should be horizontal.