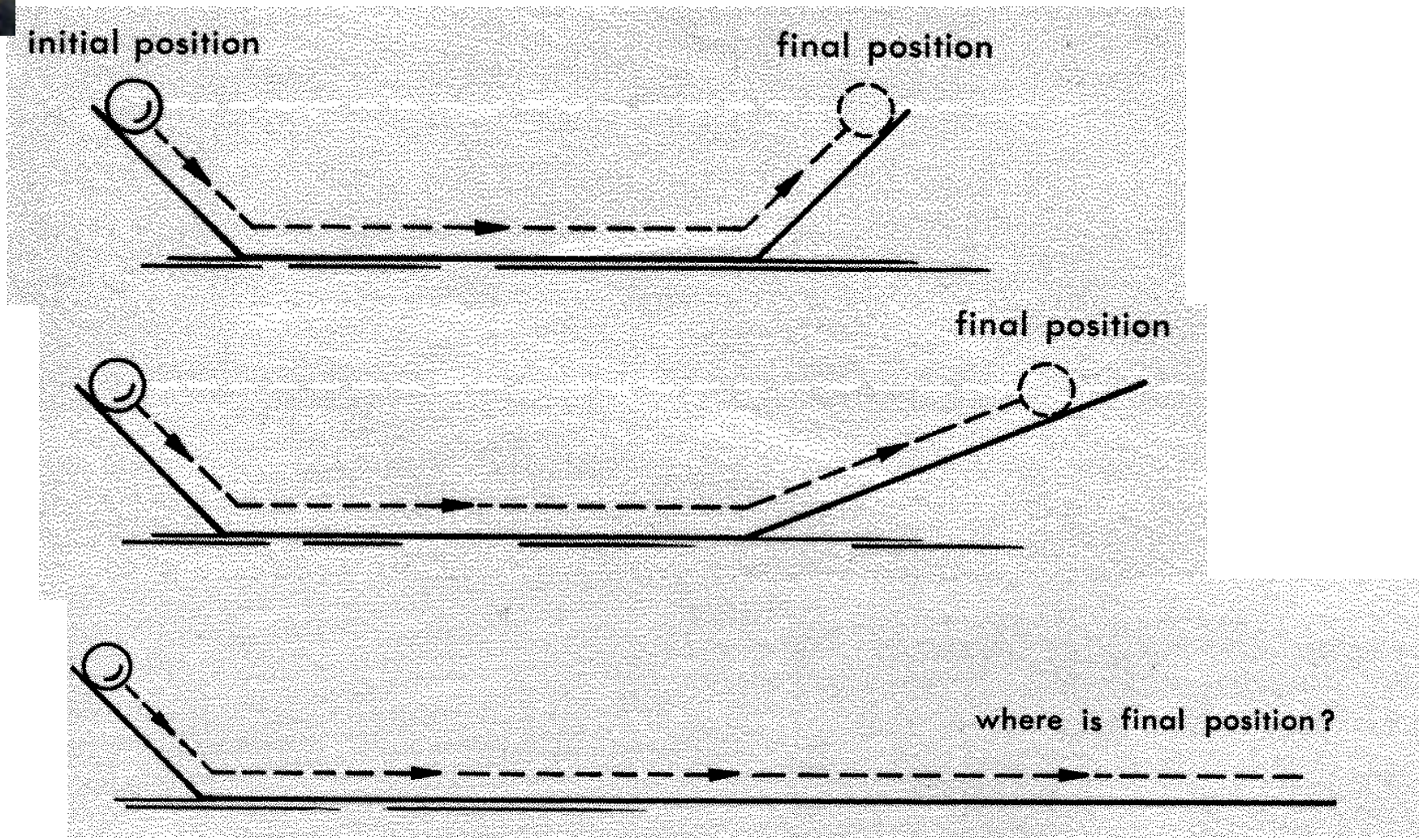
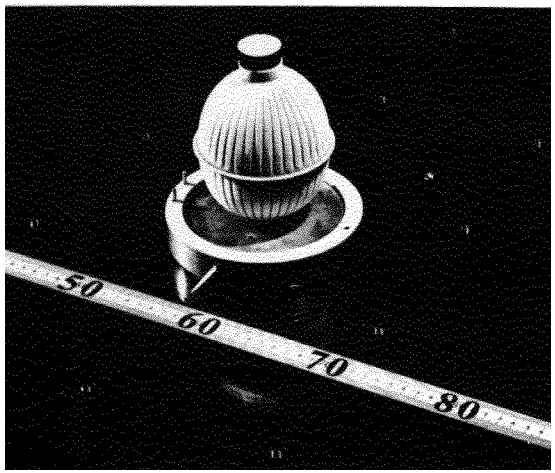
Forces

Galieo Galilei



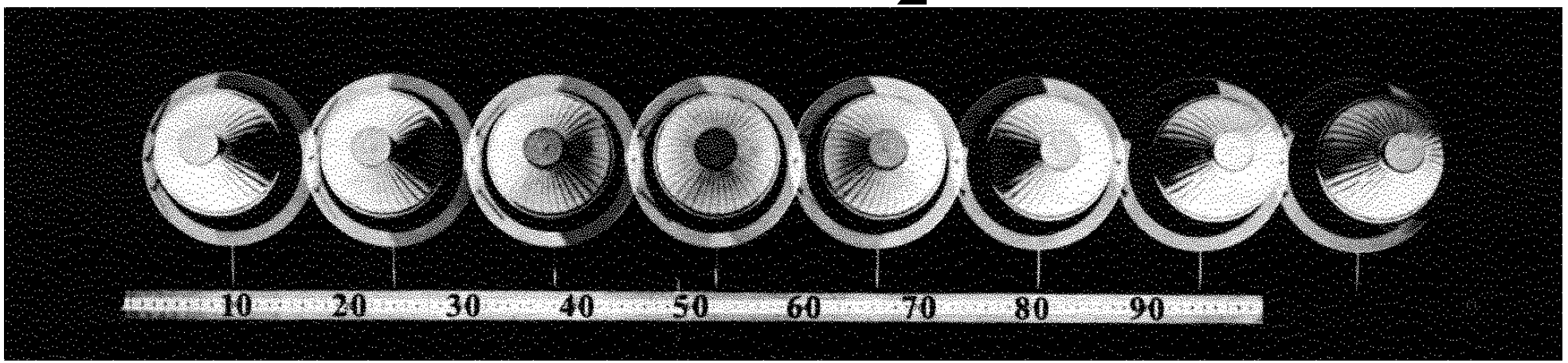
- Would it go on forever?

Frictionless Puck



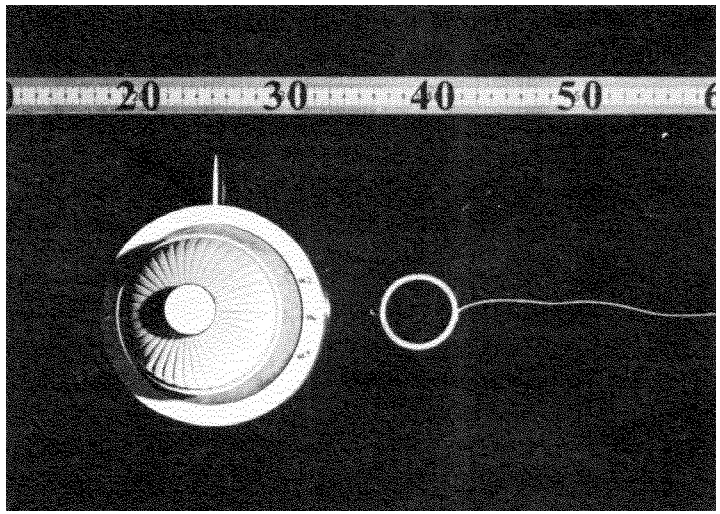
Dry ice inside

Hole in bottom lets CO_2 gas form a cushion

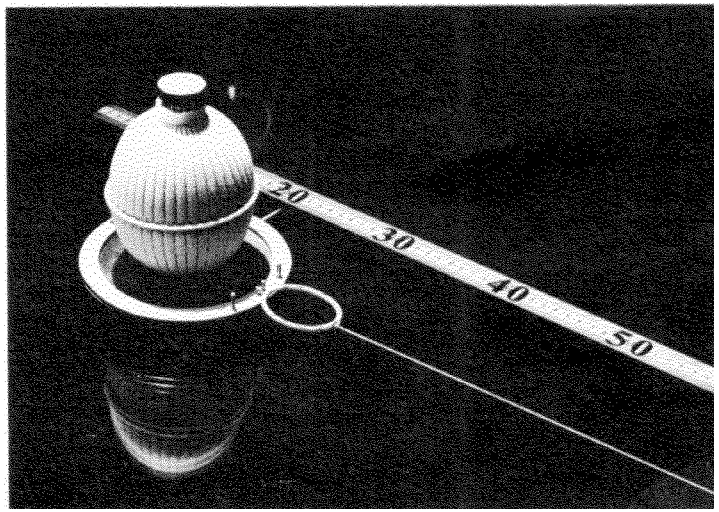


Nearly frictionless motion gives a uniform velocity.

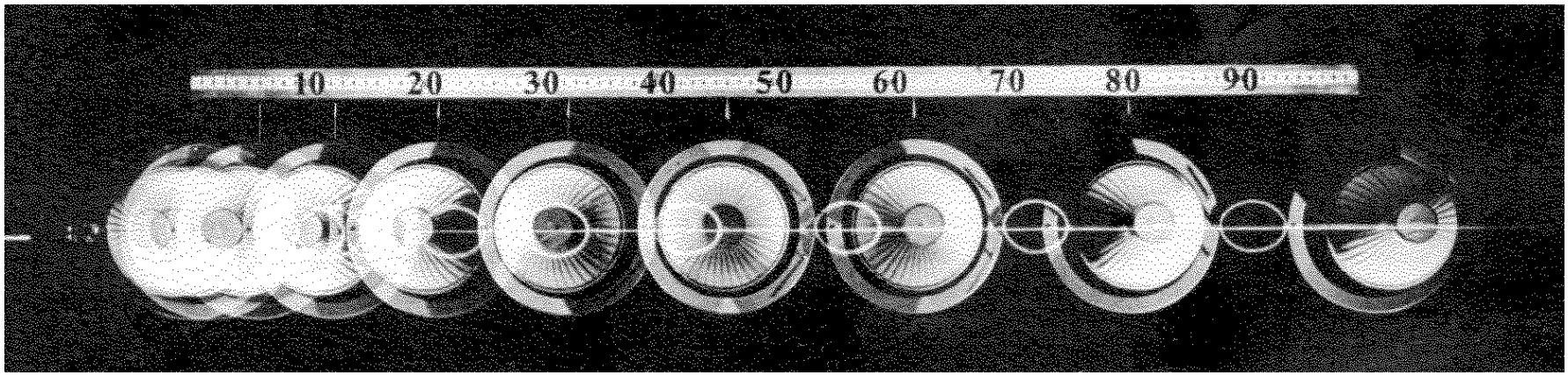
Elastic loop shows force



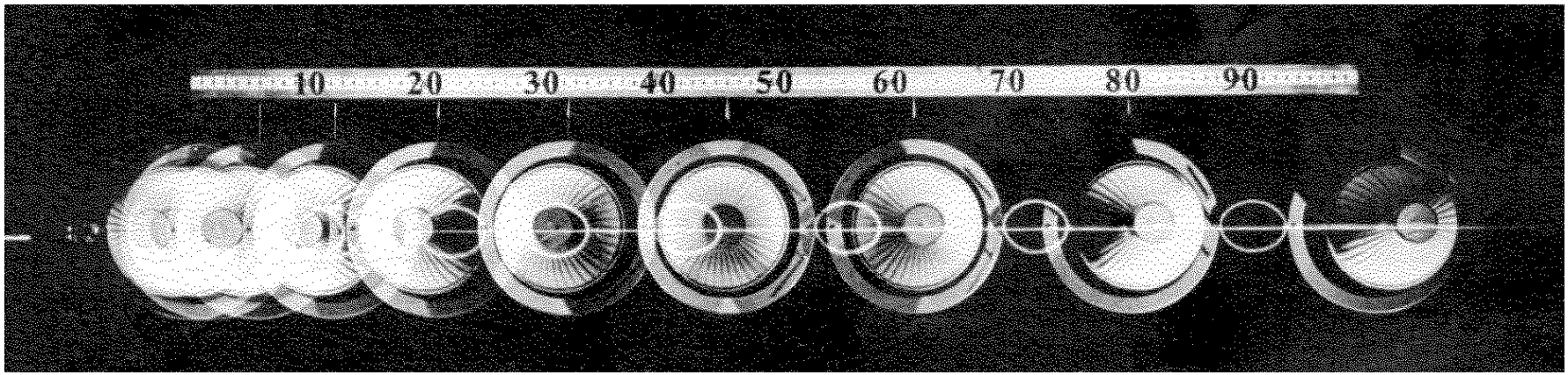
no force



force

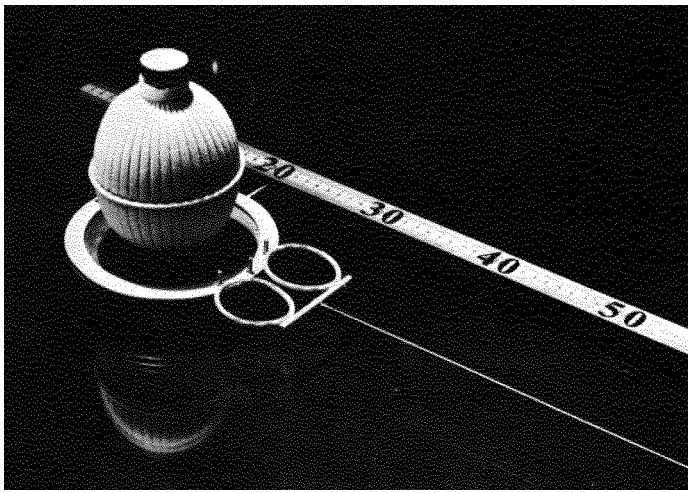


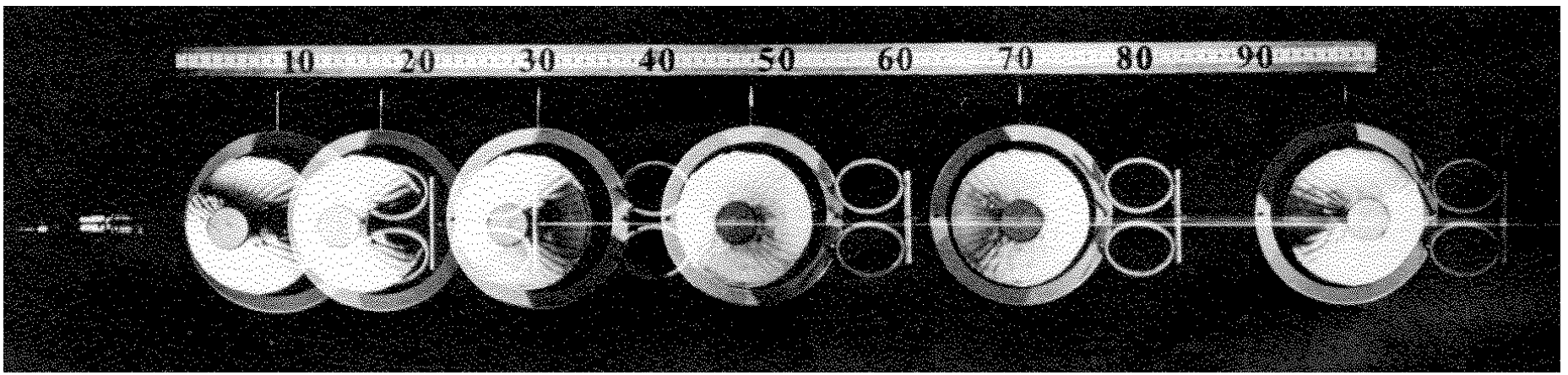
INTERVAL NO.	POSITION x(cm)	AVERAGE VELOCITY IN INTERVAL $\Delta x/\Delta t = v$(cm/flash)	CHANGE IN AVERAGE VELOCITY Δv(cm/flash)
1	4.1	4.1	
			2.2
2	10.4	6.3	
			2.5
3	19.2	8.8	
			2.4
4	30.4	11.2	
			2.4
5	44.0	13.6	
			2.5
6	60.1	16.1	
			2.4
7	78.6	18.5	



$$\Delta v = (2.4\text{cm/flash}^2)\,\Delta t$$

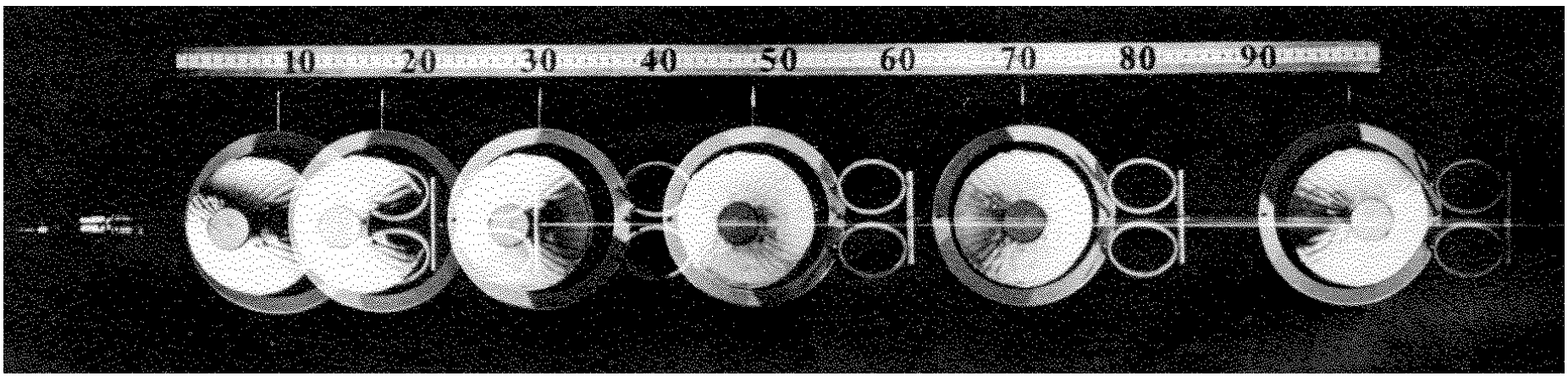
More force





INTERVAL NO.	POSITION x(cm)	AVERAGE VELOCITY IN INTERVAL $\Delta x/\Delta t = v$(cm/flash)	CHANGE IN AVERAGE VELOCITY Δv(cm/flash)
1	8.4	8.4	
			4.7
2	21.5	13.1	
			4.7
3	39.3	17.8	
			4.8
4	61.9	22.6	
			4.8
5	89.3	27.4	

$$\Delta v = (4.8\text{cm/flash}^2)\,\Delta t$$



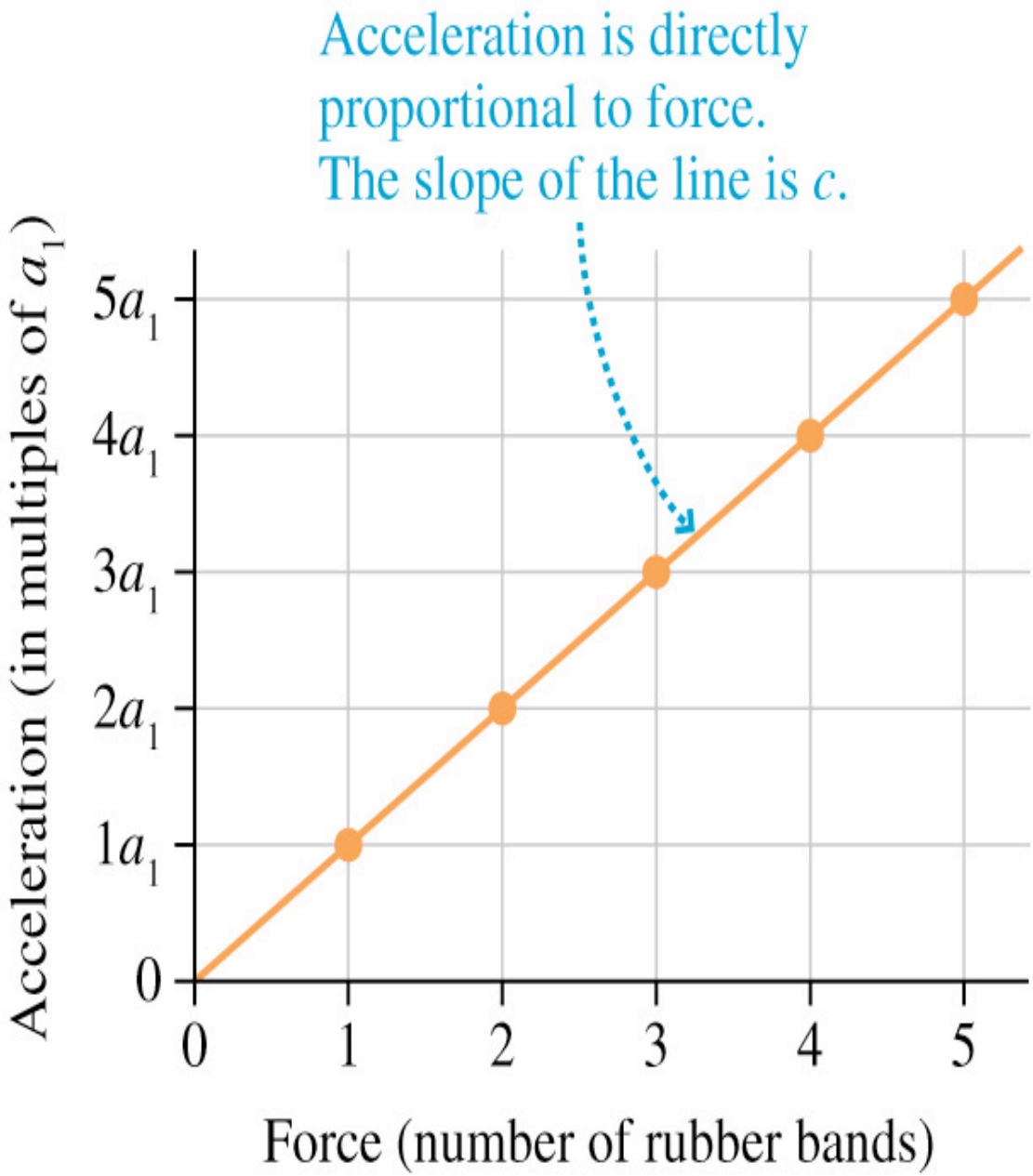
Conclusions

- A single unbalanced force causes a constant acceleration
- More force causes more acceleration
- We can use the acceleration of a standard mass (kg) as measure of force
  - a force that accelerates a 1 kilogram mass 1 m/s^2 is called a newton (N)

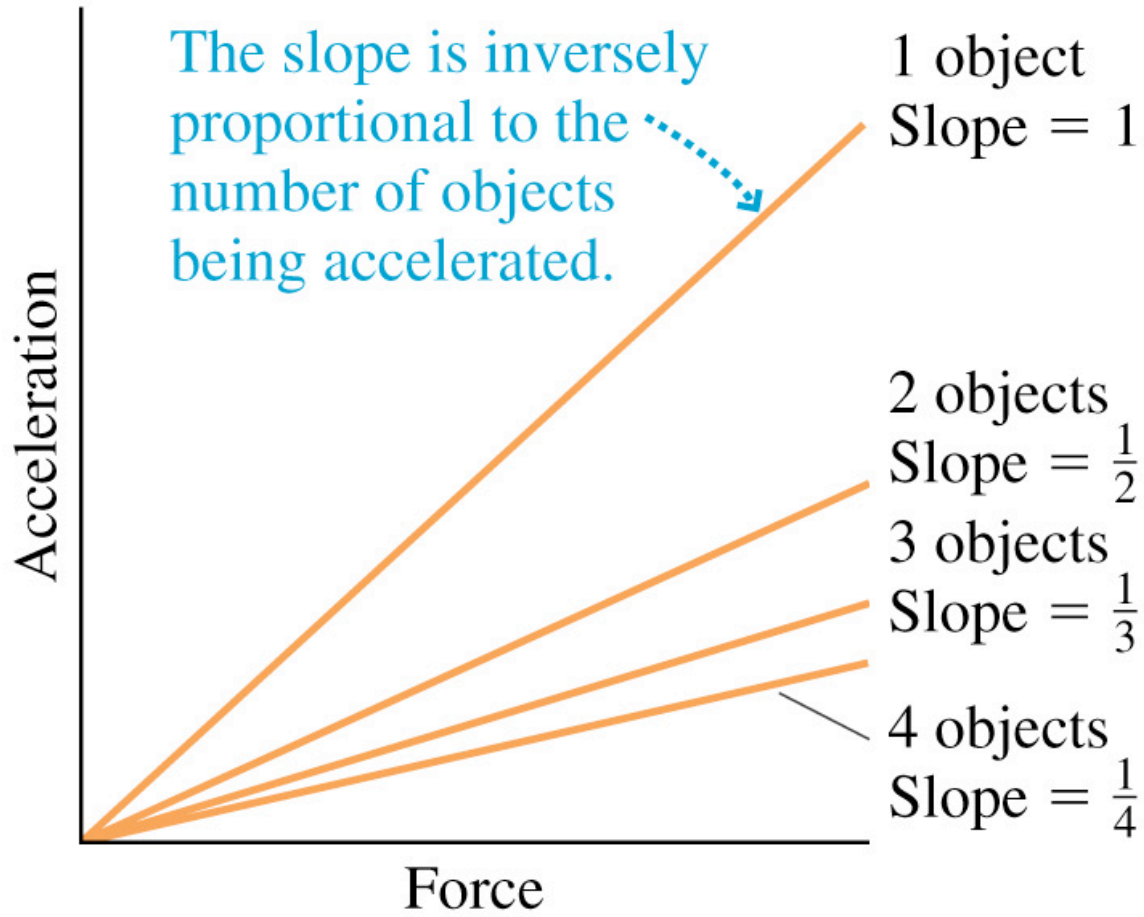
For example

- 24 flashes in 10 s : $1 = {}^{24\text{ flash}}/_{10\text{ s}}$
- 1 loop of force
  - $\Delta v = (2.4\text{ cm/flash}^2)(24\text{ flash}/10\text{ s})^2\,(0.01\text{m/cm}) = 0.14\text{ m/s}^2$
  - If the puck is 1 kg, $F = 0.14$ N.
  - 2 loops gives 0.28 N : twice the force

Acceleration and force



Acceleration and stuff



Newton's 2nd law

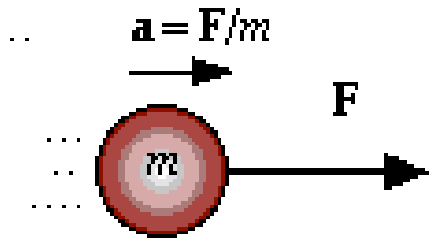
- If the same amount of force on another object gives 1/2 the acceleration
- We say that object has 2x the mass
- for the same force : **acceleration ∝ 1/m**
- for the same mass : **acceleration ∝ *F***
- Conclusion: $a = F/m$ or $F = ma$
  - Unit of force = $\mathrm{kg} \cdot \mathrm{m}/\mathrm{s}^2$

Does it work in 3D?

- $F = ma$ is a scalar equation derived from observations in 1 dimension.
- Acceleration is a vector.
- is the vector equation $\mathbf{F} = m\mathbf{a}$ also true?
  - Is **F** always in same direction as **a**?
  - Do forces add like vectors?

Newton's 2nd law is experimental

How do Forces Add ?



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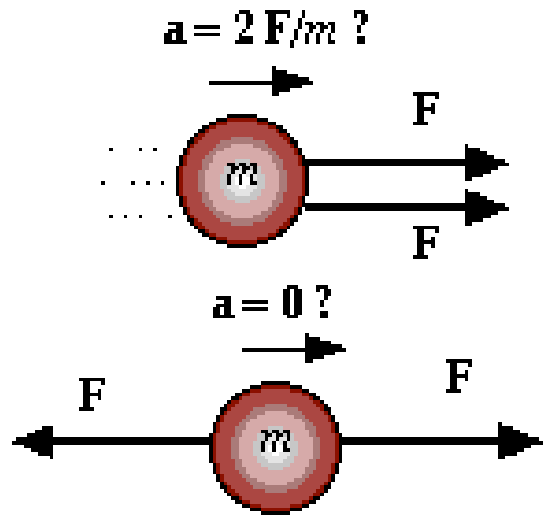

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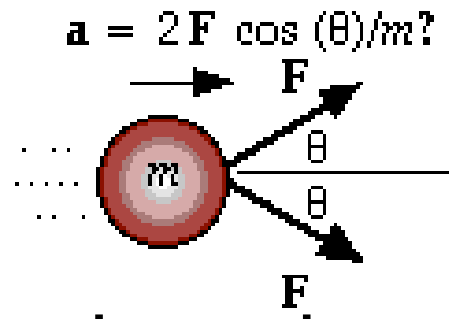

See the web page "How forces add"

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