

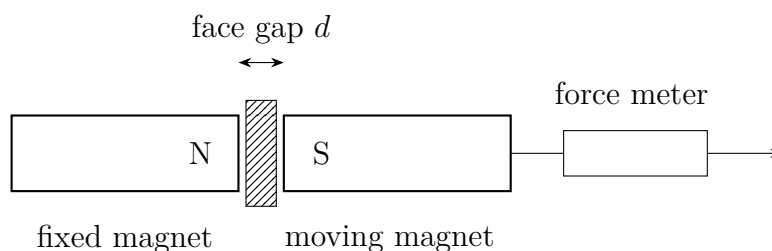
Magnetic force and separation

Name: _____ Class: _____ Date: _____

Aim Test an empirical power law over a measured distance range. Allow 60–75 minutes.

Model $F = K(d/d_*)^n$, with $d_* = 1$ m. Then $\log_{10}(F/F_*) = n \log_{10}(d/d_*) + b$, where $F_* = 1$ N and $K = F_* 10^b$. A log–log gradient gives the exponent n . Real bar magnets do not behave as two isolated point poles.

Apparatus Two bar magnets, force meter, clamp, tape/string, six card spacers, micrometer and ruler.



Safety Clamp firmly and pull slowly along the magnet axis. Keep fingers clear of snapping magnets. Keep magnets away from sensitive equipment and follow the school's guidance for medical implants.

1 Set up and measure

1. Zero the force meter. Align opposite poles face-to-face so they attract. Attach the moving magnet securely; keep the pulling direction along the axis.
2. Measure each spacer stack with the micrometer, using the ratchet gently. The gap d is the actual stack thickness between the facing surfaces, not magnet-centre distance.
3. Insert one stack. Increase the pull slowly and record the peak force just before separation. Do not jerk the meter or exceed its range.
4. Repeat three times with the same stack, reseating the magnets each time. Change to at least six different gaps, retaining orientation and alignment.
5. Pilot the largest gap: its force must remain clearly above resolution. Do not assume the exponent will be -2 .

2 Record and process

Micrometer zero error: _____ Force resolution: _____.

d/mm	F_1/N	F_2/N	F_3/N	$\bar{F}/\text{N}$

d/m	$\log_{10}(d/d_*)$	$\log_{10}(\bar{F}/F_*)$	$\Delta F/\text{N}$

Controls Explain how you maintained alignment and a consistent separation method.

Uncertainty Combine the repeat spread and meter resolution into a justified ΔF . Record Δd .

3 Graph

Plot $\log_{10}(\bar{F}/F_*)$ against $\log_{10}(d/d_*)$. Use $\Delta \log_{10} F \simeq \Delta F/(F \ln 10)$ for vertical bars and $\Delta \log_{10} d \simeq \Delta d/(d \ln 10)$ for horizontal bars. Look for curvature.



Choose scales and label both axes with quantities and units. Mark a large gradient triangle on the best-fit line where appropriate.

4 Analyse and evaluate

1. Find n and its uncertainty using an extreme acceptable line. Does one straight line describe the full measured range? Refer to points, error bars and any pattern in the deviations.

2. Find b and K . Use your model to predict force at a distance within your measured range. Show the distance in metres and use the correct log base.

3. The source suggests predicting force at $d = 0.20$ m. Calculate the formal prediction, then explain why this long extrapolation may be unreliable. Would agreement with $n = -2$ prove an inverse-square law for all distances?

4. Plan a more sensitive repulsion experiment using a digital balance. State the zero reading, measured separation and conversion $F = \Delta mg$ with mass in kg. Give two controls and two limitations of the original method.

Before you leave Return the apparatus, clear the bench and submit your recorded data.