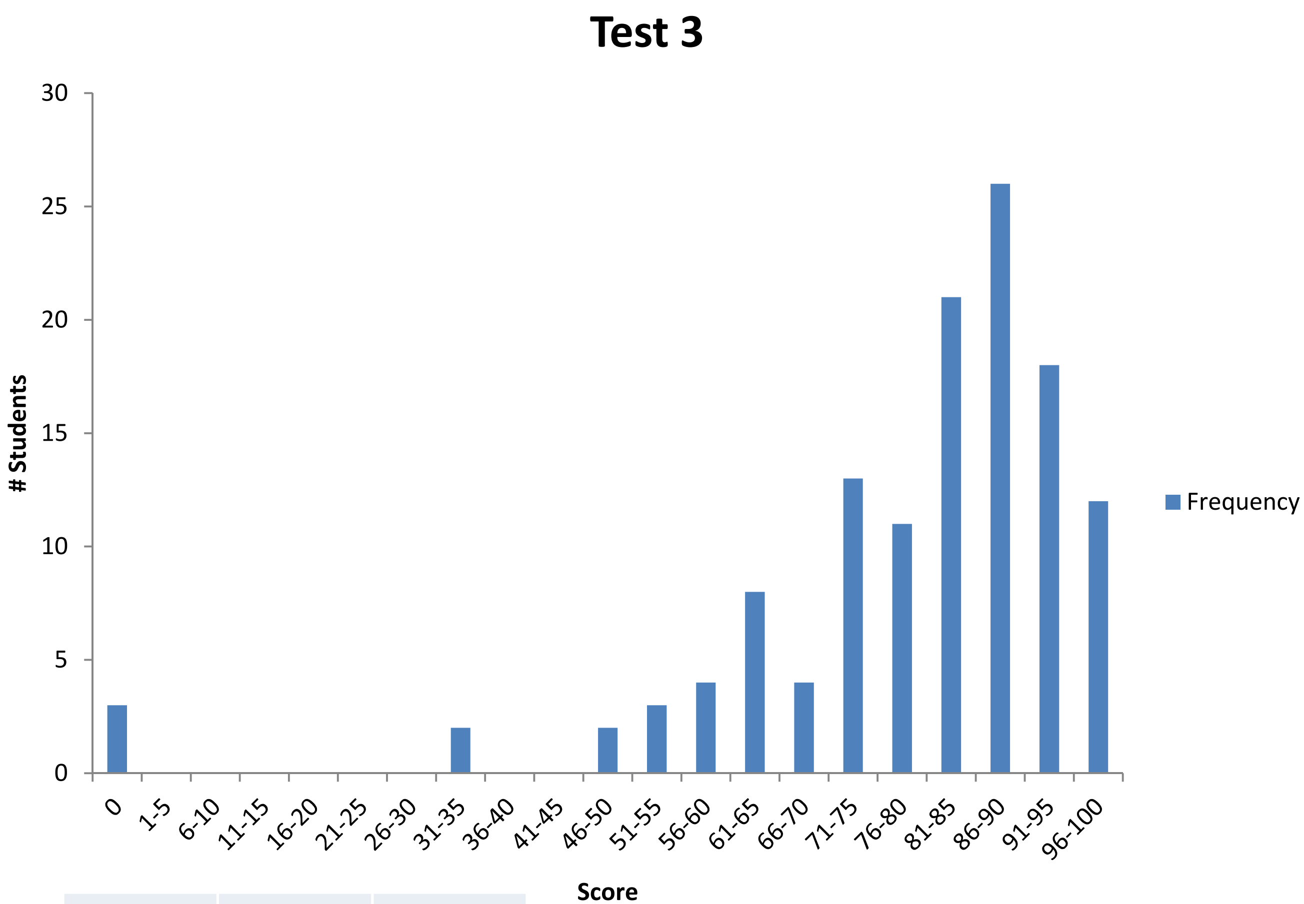
Class 34. Force between two currents and solenoid



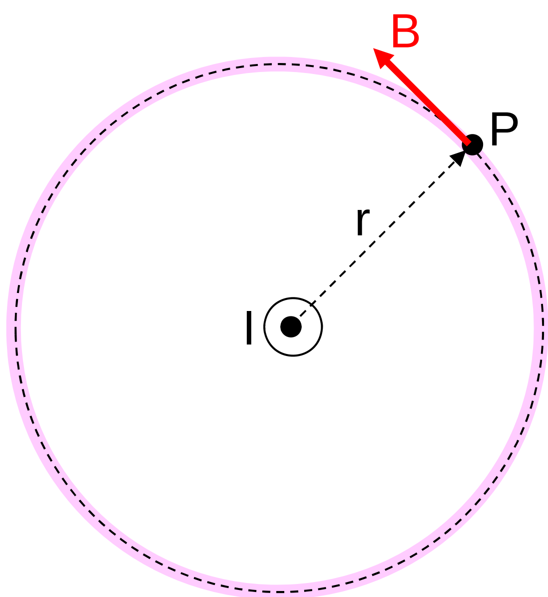
Bin	# students
0	3
1-5	0
6-10	0
11-15	0
16-20	0
21-25	0
26-30	0
31-35	2
36-40	0
41-45	0
46-50	2
51-55	3
56-60	4
61-65	8
66-70	4
71-75	13
76-80	11
81-85	21
86-90	26
91-95	18
96-100	12

		# students
92-100	A	26
80-91	B	54
55-79	C	38
36-54	D	4
0-35	E	5
		127 students

Total number of students: 127
Class average: 79.2
Sample standard deviation: 18.5

Top ¼ percentile: 90
Median: 84
Top ¾ percentile: 73

Magnetic field due to a long wire



Want to calculate the magnetic field B at point P.

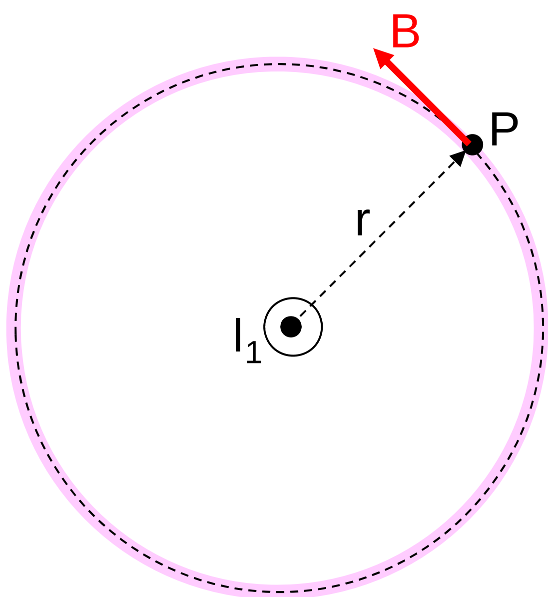
By symmetry argument, B is in the plane of the paper (infinite long wire), has the same magnitude for all points on the dotted circular loop (azimuthal symmetry), and tangent to the circular loop (so cos θ=1).

$$\therefore \oint \vec{B} \cdot d\vec{s} = B \cdot 2\pi\, r$$

Ampere's Law: $\oint \vec{B} \cdot d\vec{s} = \mu_0\, I \Rightarrow\ B \cdot 2\pi\, r = \mu_0\, I$

$$\Rightarrow\ B = \frac{\mu_0\, I}{2\pi\, r}$$

Magnetic Force Between Two Parallel Long Wires

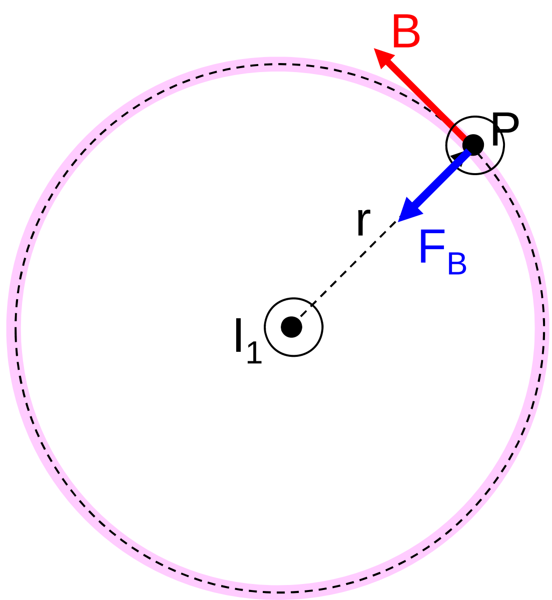


Magnetic field at point P due to I_1:

$$B = \frac{\mu_0 \, I_1}{2\pi \, r}$$

If another current I_2 parallel to I_1 is passing through point P, it will experience a force because of the field there.

Magnetic Force Between Two Parallel Long Wires



Magnetic field at point P due to I_1:

$$B = \frac{\mu_0 \, I_1}{2\pi \, r}$$

If another current I_2 parallel to I_1 is passing through point P, it will experience a force because of the field there.

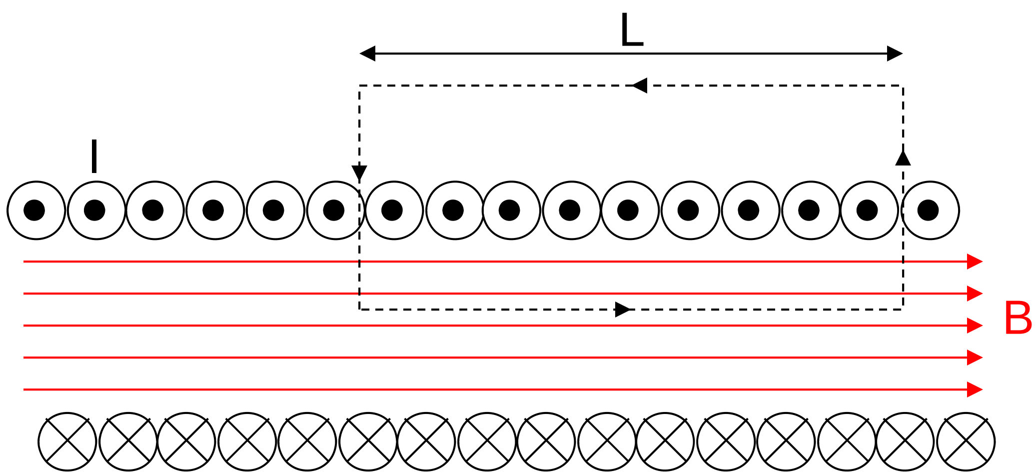
$$\vec{F}_B = I_2 \vec{L} \times \vec{B} \;\Rightarrow\; F_B = I_2 BL \sin 90^o = I_2 BL$$

$$\Rightarrow\; F_B = I_2 L \cdot \frac{\mu_0 I_1}{2\pi \, r}$$

$$\Rightarrow\; \frac{F_B}{L} = \frac{\mu_0 I_1 I_2}{2\pi \, r}$$

Force is attractive if the two currents are in the same direction, repulsive if the two currents are in opposite direction.

Solenoid



If n = number of turns per unit length

$$\therefore \oint \vec{B} \cdot d\vec{s} = B \cdot L$$

Ampere's Law: $\oint \vec{B} \cdot d\vec{s} = \mu_0 \, I \Rightarrow \; B \cdot L = \mu_0 \, (nL) \, I$

$$\Rightarrow \boxed{B = \mu_0 \, n \, I}$$

Note that B is proportional to the number of turns per unit length, but not the total number of turns.