Based on the two-name eponym principle: $P = \frac{F}{A}$

$P$ is for Pressure

Applanation Tonometry
Based on the *Imbert-Fick* principle: $P = \frac{F}{A}$
Based on the **Imbert-Fick principle**: $P = \frac{F}{A}$

- Pressure inside a sphere equals force needed to flatten its surface divided by the area of flattening.

$I$-F Principle in words:

- $F$ stands for what the...

- $A$ stands for what the $A$ stands for
Based on the **Imbert-Fick principle**: \( P = \frac{F}{A} \)

- Pressure inside a sphere equals the force needed to flatten its surface divided by the area of flattening.
Based on the *Imbert-Fick* principle: \( P = \frac{F}{A} \)

- Pressure inside a sphere equals **force needed to flatten its surface** divided by the **area of flattening**
- Assumes surface is **two words**, and **(cornea is neither, obviously)**
Based on the **Imbert-Fick principle**: \[ P = \frac{F}{A} \]

- Pressure inside a sphere equals force needed to flatten its surface divided by the area of flattening.
- Assumes surface is infinitely thin, and dry (cornea is neither, obviously).
Based on the \textit{Imbert-Fick} principle: $P = \frac{F}{A}$

- Pressure inside a sphere equals \textit{force needed to flatten its surface} divided by the \textit{area of flattening}.
- Assumes surface is \textit{infinitely thin}, and \textit{dry} (cornea is neither, obviously).
- $K$ thickness $\rightarrow$ \textit{resists applanation} $\rightarrow$ \textit{increase} vs \textit{decrease} IOP reading.
Based on the *Imbert-Fick* principle: \( P = \frac{F}{A} \)

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For the Imbert-Fick principle to hold, the only force resisting applanation should be the pressure within the sphere. However, real objects such as the cornea have *intrinsic* resistance to deformation owing to their physical nature, ie, because they’re made of ‘stuff.’ This inherent structural resistance of the cornea will be additive to whatever pressure is inside the eye, thereby causing the pressure reading to be falsely *high*. (And the thicker the cornea is, the higher the reading will be.)
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- Assumes surface is infinitely thin, and dry (cornea is neither, obviously).
  - K thickness → resists applanation → *increases* IOP reading
  - Tear film → capillary attraction → *decreases* IOP reading
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On the other hand: The first ocular structure encountered by the applanator tip is the tear film. When contact with the tear film is made, a fluid bridge forms between the cornea and the tip. Surface tension of the water in this fluid bridge produces *capillary attraction*, which exerts a slight ‘pull’ on the applanator tip, drawing it toward the cornea. Because this force is drawing the applanator tip forward, it is causing the pressure reading to be falsely low.
Based on the *Imbert-Fick principle*: \( P = \frac{F}{A} \)

- Pressure inside a sphere equals force needed to flatten its surface divided by the area of flattening.
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- K thickness → resists applanation → *increases* IOP reading
- Tear film → capillary attraction → *decreases* IOP reading

To be useful, an applanator-type device has to account for these factors. Fortunately, the brilliant Dr. Goldmann was (mostly) up to the challenge…
Based on the **Imbert-Fick principle**: \( P = \frac{F}{A} \)

- Pressure inside a sphere equals force needed to flatten its surface divided by the area of flattening.
- Assumes surface is infinitely thin, and dry (cornea is neither, obviously).
- K thickness → resists applanation → increases IOP reading.
- Tear film → capillary attraction → decreases IOP reading.
- Dr. Goldmann realized if the area applanated by the device is \( #.## \) mm\(^2\), capillary attraction and corneal thickness would cancel each other out (assuming CCT is \( \# \) (µm)).

\((CCT = \text{Central corneal thickness})\)
Based on the **Imbert-Fick principle**: \[ P = \frac{F}{A} \]

- Pressure inside a sphere equals force needed to flatten its surface divided by the area of flattening.
- Assumes surface is infinitely thin, and dry (cornea is neither, obviously).
  - K thickness → resists applanation → increases IOP reading
  - Tear film → capillary attraction → decreases IOP reading
- Dr Goldmann realized if the area applanated by the device is **3.06** mm², capillary attraction and corneal thickness would cancel each other out (assuming CCT is **520**).
Based on the *Imbert-Fick* principle:  \[ P = \frac{F}{A} \]

- Pressure inside a sphere equals force needed to flatten its surface divided by the area of flattening.
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Dr. Goldmann realized if the area applanated by the device is 3.06 mm\(^2\), capillary attraction and corneal thickness would cancel each other out (assuming CCT is 520).

- Goldmann believed CCT was ~520, with little variation.

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**Applanation Tonometry**
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  - Goldmann believed CCT was \( \sim 520 \), with little variation

(We now know that CCT averages about 550, but that it varies widely among individuals)
Based on the *Imbert-Fick* principle: $P = \frac{F}{A}$

- Pressure inside a sphere equals force needed to flatten its surface divided by the area of flattening.
- Assumes surface is infinitely thin, and dry (cornea is neither, obviously).
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Dr Goldmann realized if the area applanated by the device is 3.06 mm$^2$, capillary attraction and corneal thickness would cancel each other out (assuming CCT is 520).

- Goldmann believed CCT was ~520, with little variation.
- When mires line up, applanated area = 3.06 mm$^2$. 

Applanation Tonometry

What’s the deal with using a prism to split the circle, and then lining up the mires?

- **When mires line up, applanated area = 3.06 mm²**
Applanation Tonometry

What's the deal with using a prism to split the circle, and then lining up the mires?

When performing Goldmann applanation tonometry, the tip of the applanator pushes against the cornea. The force with which it does so is controlled by the examiner (via the knob on the side of the device). As the tip presses against the cornea, it creates a circle of fluorescein corresponding to the outer edge of the area of the cornea that is being flattened by the tip. Thus, when the pressure inside the eye is higher than the pressure being applied by the applanator, only a small area of the cornea (corresponding to the very end of the applanator tip) is compressed, and the size of the resulting fluorescein circle is small. Likewise, when IOP is less than the pressure applied by the device, a substantial portion of the applanator tip compresses the cornea, and the resulting fluorescein circle is relatively large. To measure IOP, you must modify the pressure being applied by the device (ie, turn the knob) until the area of the fluorescein circle is exactly 3.06 mm². But how can you tell when this has been accomplished?

- When mires line up, applanated area = 3.06 mm²
What's the deal with using a prism to split the circle, and then lining up the mires?
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One way would be to inscribe a 3.06 mm² circular reticule on the optics of the slit lamp, but this would be visible during the rest of the slit-lamp exam--not ideal. So instead, a prism is used to split the image of the circle in half, with the power of this prism set so that the two half-circles will exactly overlap when the circle has an area of 3.06 mm².

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One way would be to inscribe a 3.06 mm² circular reticule on the optics of the slit lamp, but this would be visible during the rest of the slit-lamp exam—not ideal. So instead, a prism is used to split the image of the circle in half, with the power of this prism set so that the two half-circles will exactly overlap when the circle has an area of 3.06 mm². As the pressure applied by the device is manipulated (ie, as you turn the knob on the applanator), it looks like the mires are moving toward or away from one another—but they’re not. Instead, what’s really happening is the fluorescein circle is getting larger or smaller. (Next time you applanate someone, take note of the heights of the mires as you adjust the knob, and you’ll be better able to appreciate the fact that it’s the size of the circle that’s actually changing.)

- When mires line up, applanated area = 3.06 mm²
More on Applanation Tonometry

- Reading will be falsely **LOW** if:
  - Cornea is in a pathologic state
More on Applanation Tonometry

- Reading will be falsely **LOW** if:
  - Cornea is **edematous**
More on Applanation Tonometry

Reading will be falsely **LOW** if:
- Cornea is **edematous**

But an edematous cornea is a thick cornea, and we all know that thicker corneas yield falsely **high** applanation pressures. What gives?
More on Applanation Tonometry

- Reading will be falsely **LOW** if:
  - Cornea is **edematous**

**But an edematous cornea is a thick cornea, and we all know that thicker corneas yield falsely **high** applanation pressures. What gives?**

Not all thick corneas are biomechanically equivalent. A ‘naturally thick’ (i.e., thicker-than-normal in the non-pathologic state) cornea yields falsely high applanation readings because it has greater intrinsic biomechanical resistance compared with thinner corneas. On the other hand, an edematous cornea undergoes a **decrease** in its native biomechanical resistance (think of it as being ‘gooey’). Thickness in and of itself is not the issue.
More on Applanation Tonometry

Reading will be falsely **LOW** if:

- Cornea is **edematous**
- Applanation performed over a **oops**
More on Applanation Tonometry

- Reading will be falsely **LOW** if:
  - Cornea is **edematous**
  - Applanation performed over a **soft CL** (contact lens)
More on Applanation Tonometry

- Reading will be falsely **LOW** if:
  - Cornea is *edematous*
  - Applanation performed over a *soft CL*
  - After *surgery* (changes scleral rigidity)
More on Applanation Tonometry

- Reading will be falsely **LOW** if:
  - Cornea is **edematous**
  - Applanation performed over a **soft CL**
  - After **scleral buckling** surgery (changes scleral rigidity)
More on Applanation Tonometry

- Reading will be falsely **LOW** if:
  - Cornea is **edematous**
  - Applanation performed over a **soft CL**
  - After **scleral buckling** surgery (changes scleral rigidity)
  - Too **much vs little** fluorescein in tear film
More on Applanation Tonometry

- Reading will be falsely LOW if:
  - Cornea is edematous
  - Applanation performed over a soft CL
  - After scleral buckling surgery (changes scleral rigidity)
  - Too much fluorescein in tear film

Applanation Tonometry
More on Applanation Tonometry

Reading will be falsely **LOW** if:
- Cornea is edematous
- Applanation performed over a soft CL
- After scleral buckling surgery (changes scleral rigidity)
- Too much fluorescein in tear film

Reading will be falsely **HIGH** if:
- Performed over a pathologic state
More on Applanation Tonometry

Reading will be falsely **LOW** if:
- Cornea is *edematous*
- Applanation performed over a *soft CL*
- After *scleral buckling* surgery (changes scleral rigidity)
- Too much fluorescein in tear film

Reading will be falsely **HIGH** if:
- Performed over a *corneal scar*
More on Applanation Tonometry

- Reading will be falsely \textit{LOW} if:
  - Cornea is \textit{edematous}
  - Applanation performed over a \textit{soft CL}
  - After \textit{scleral buckling} surgery (changes scleral rigidity)
  - Too much fluorescein in tear film

- Reading will be falsely \textit{HIGH} if:
  - Performed over a \textit{corneal scar}
  - Too\textit{ much} fluorescein in tear film
More on Applanation Tonometry

- Reading will be falsely LOW if:
  - Cornea is edematous
  - Applanation performed over a soft CL
  - After scleral buckling surgery (changes scleral rigidity)
  - Too much fluorescein in tear film

- Reading will be falsely HIGH if:
  - Performed over a corneal scar
  - Too little fluorescein in tear film