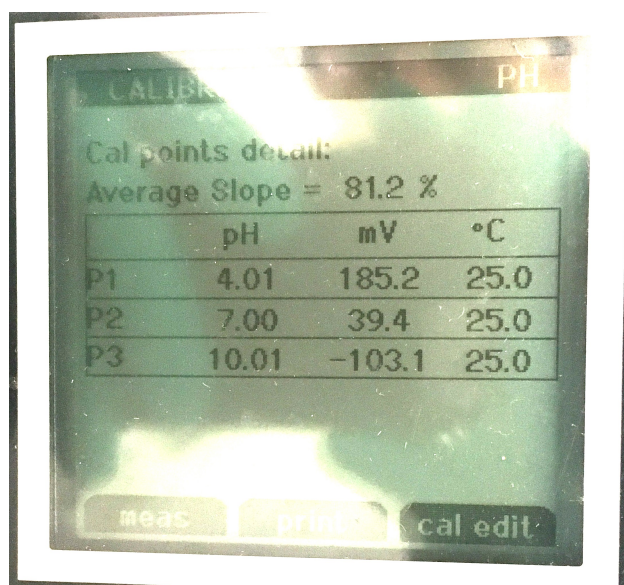


# 2019-08-14-measure-1-to-1-plate pH meter calibration

*Michael J. Braus*

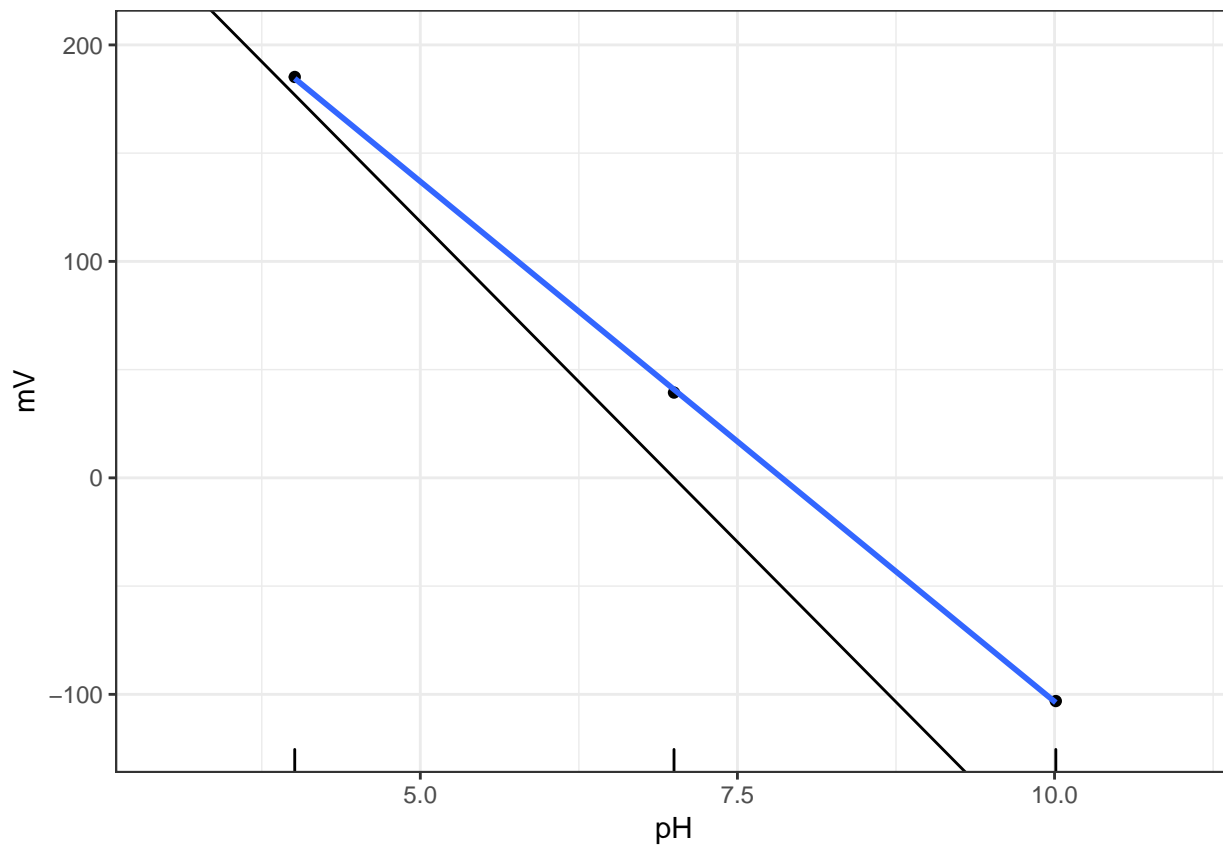
*2019-09-20*

Working with a pH probe on 2019-08-14, its meter reported that the calibration looked like this:



The meter is less likely to be in error than the probe. I've plotted this and run my own regression, which shows a much higher fit than 81.2%. They called this "Average Slope", but this is not an  $r^2$  or other regression metric. They assume that a "good probe" will follow not only a "perfect" calibration curve, but the intercept of this curve will also have a "perfect" slope and intercept. This means no matter how straight the curve is, your probe's "average slope" can still be in error from "how a good probe should behave". This is based on Nernst potential (see below).

```
library(ggplot2)
pH <- c(4.01, 7.00, 10.01)
mV <- c(185.2, 39.4, -103.1)
df <- data.frame(x=pH, y=mV)
ggplot(df, aes(x=x, y=y, label=y)) +
  geom_point() + geom_rug(sides="b") +
  geom_smooth(method="lm", se=FALSE) +
  xlab("pH") + ylab("mV") + theme_bw() +
  ylim(-120, 200) + xlim(3, 11) +
  geom_abline(intercept = 414.12, slope = -59.16)
```



The black line is the “perfect theoretical slope”:  $-59.16[\text{mV}/\text{pH}]$ .<sup>1</sup>

```
summary(lm(mV~pH))
```

```
##
## Call:
## lm(formula = mV ~ pH)
##
## Residuals:
##      1      2      3
##  0.7125 -1.4203  0.7078
##
## Coefficients:
##              Estimate Std. Error t value Pr(>|t|)
## (Intercept)   377.165      3.043   123.9  0.00514 **
## pH           -48.049      0.410  -117.2  0.00543 **
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
## Residual standard error: 1.74 on 1 degrees of freedom
```

<sup>1</sup>Am I the only one dubious about the proposition that 0[mV] is 7.0[pH], *i.e.* neutral at nil?

```
## Multiple R-squared:  0.9999, Adjusted R-squared:  0.9999
## F-statistic: 1.373e+04 on 1 and 1 DF,  p-value: 0.005432
```

The model above says this probe (#1) is performing at  $-48.049[\text{mV}/\text{pH}]$ . I suspect that the probe I'm using (#1) has been used enough times to warrant cleaning. Because it reports a low ( $< 92\%$ ) average slope, this does not mean that the pH values are wrong from it when using the Orion pH meter. It just means the probe behaves differently from a “fresh” one.