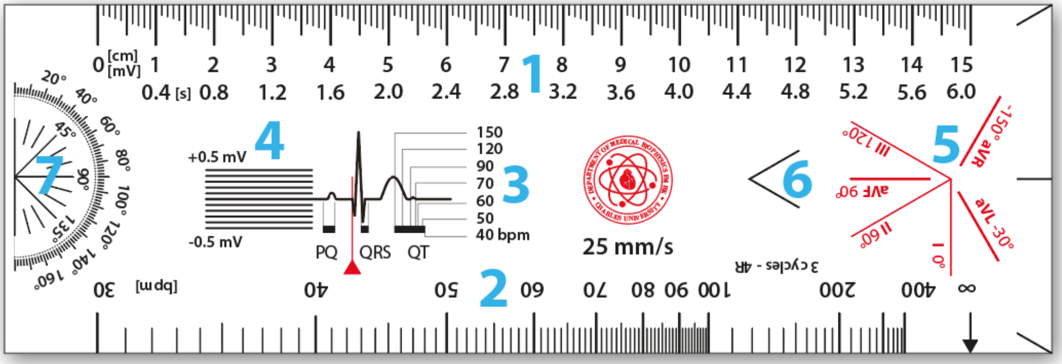
# Ruler for working with electrocardiogram

*Designed for a “paper speed” of 25 mm/s*

**Ruler (6 x 18 cm) shows**

1. a linear metric scale that allows measurement of distances or amplitudes (mV) for an electrocardiogram with a voltage calibration of 10 mm/mV
2. a hyperbolic scale which allows the reading of heart rate
3. a schematic representation of the electrical activity of the cardiac cycle, showing the limits of normal values for the QRS complex and the PQ and QT intervals
4. an amplitude scale for determining elevations
5. a template for the construction of the electrical axis of the heart (EAH)
6. limb leads projection angles
7. a protractor for measuring the EAH inclination

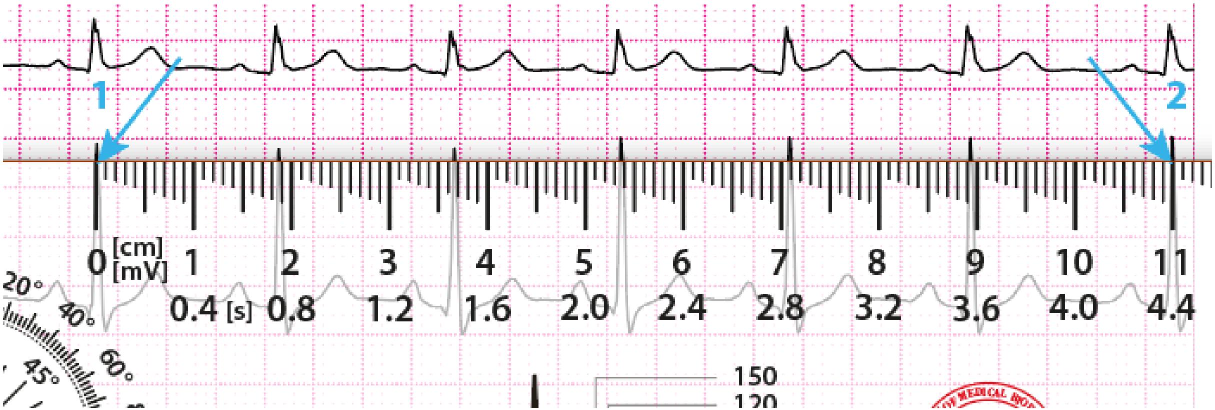


## 1. Time interval measurement

a) Set the beginning of the linear scale of the ruler to the beginning of the interval to be measured.

b) For the selected event, subtract the time interval in seconds at the bottom of the scale. One millimetre corresponds to 40 ms = 0.04 s. In the example below, the interval is 4.4 s.

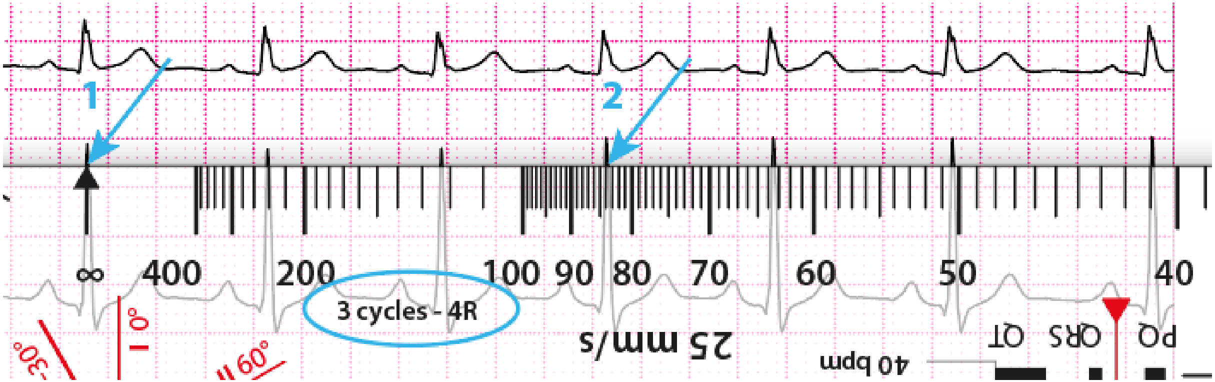
c) The scale can also be used to determine the amplitude; integer values correspond to millivolts (for a scale of 10 mm/mV).



## 2. Determination of heart rate

a) Set the black arrow on the ruler at the center of the R peak (marked by the blue arrow 1) in any lead to making the three following heart cycles visible.

b) The value read on the ruler for the third successive R beat (marked by the blue arrow 2) shows the average heart rate for the three selected cycles. *In the example below, the ruler attached to the electrocardiogram shows 84 beats per minute.*



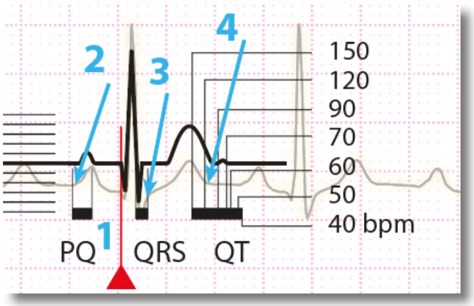
## 3. Comparison to physiological norms

c) Place the ruler on the electrocardiogram (highlighted in yellow on the image below) so that the origin of the QRS complex and the schematic Q oscillation, marked by the red triangle (marked by 1), are aligned.

d) In a physiological ECG, the onset of the P wave (marked by the blue arrow 2) should lie within or exactly at the end of the black interval marked PQ - corresponding to the norm for the PQ interval of 0.12 to 0.20 s.

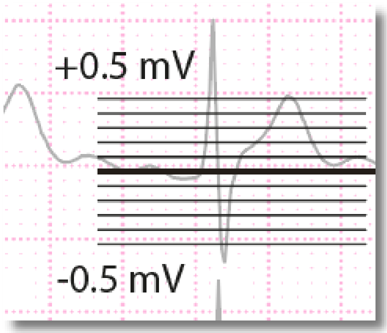
e) The end of the QRS complex (indicated by the blue arrow 3) in a physiological ECG should lie within the black interval marked QRS - corresponding to the norm for the QRS complex of 0.06 to 0.11 s.

f) The end of the T wave (indicated with a blue arrow 4) should lie in the black interval marked QT before the vertical line corresponding to the current heart rate (in our case 88 bpm). The values represent the upper limit for the QT interval in men (more stringent – shorter than for women). The norms were calculated according to Hodges. See the ruler cover or below for additional values.



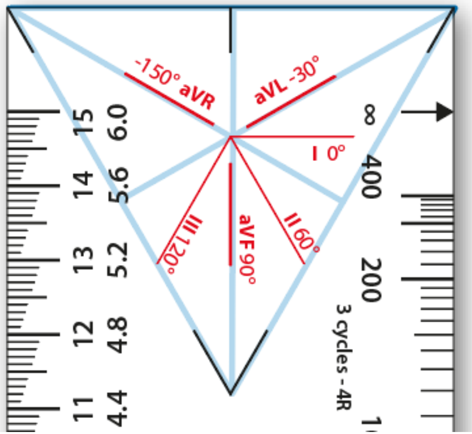
## 4. Amplitude scale for determining elevations

An extended amplitude scale of ±0.5 mV is used to read the elevations, as indicated in the figure below.



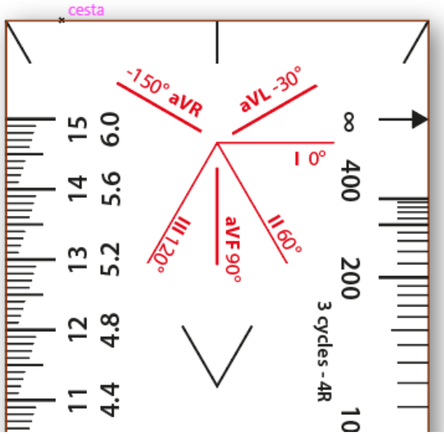
## 5. Construction of an equilateral triangle

A simplified geometric model is used to construct the electrical axis of the heart (EAH) in the frontal plane. The electrical origin of the heart is placed in the center of gravity of an equilateral triangle. The shorter side of the ruler forms one side of the triangle. Together with the marked apex can be used for the triangle construction. For easier construction of the triangle's center of gravity, the shorter side of the ruler has a middle point marked.  The figure below shows the constructed blue triangle overlaid with the ruler.



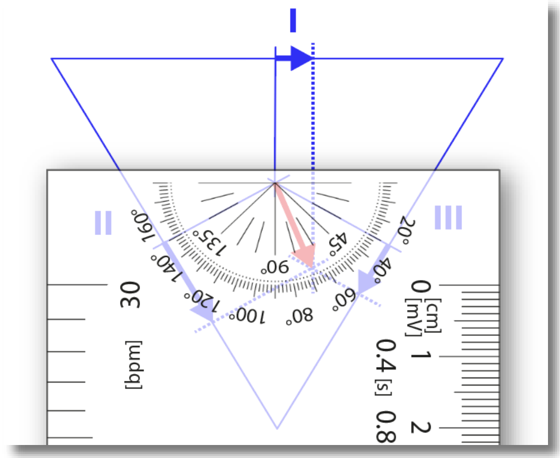
## 6. Projection angles of limb leads

The amplitudes and orientations of the individual limb leads can be used to determine the EHA. From the center of gravity of the indicated equilateral triangle, the red thin (the bipolar leads) and thick lines (the augmented Goldberger leads) show the projection angles.



## 7. Orientation of the electrical axis of the heart

The orientation of the EAH can be measured with a protractor located on the shorter side of the ruler. *In the example below, the cumulative amplitudes of the QRS complex read from the bipolar limb leads, together with a simplified geometric model, determine the EAH vector (red arrow), which is at 67° to the horizontal.*



## Back cover of the ruler

Table 1 is printed on the back cover with the lower and upper limits for the QT interval. The values were derived using the Hodges linear relationship. In our case, when we calculated the norms for individual heart rates, we used the modified relationship QT = QTcH - 1.75*(TF - 60), where we substituted for QTcH according to the norms shown in Table 2. In selecting the algorithm and norms, we used the recommendations of a study comparing the Bazett, Fridericia, Framingham, and Hodges corrections (Luo et al. 2004).

To assess the normality of measured QT interval, one can directly compare the measured value from the ECG with the cut-off for a given sex and heart rate in Table 1.

Table 1

| *bpm [t/min]* | | | *30* | *40* | *50* | *60* | *70* | *80* | *90* | *100* | *110* | *120* | *130* | *140* | *150* | *160* | *170* |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| QT [ms] | Upper limit | male | 518 | 500 | 483 | 452 | 435 | 417 | 400 | 380 | 363 | 345 | 328 | 310 | 293 | 275 | 258 |
| | | female | 523 | 505 | 488 | 459 | 442 | 424 | 407 | 382 | 365 | 347 | 330 | 312 | 295 | 277 | 260 |
| | Lower limit | male | 422 | 404 | 387 | 369 | 352 | 334 | 317 | 299 | 282 | 264 | 247 | 229 | 212 | 194 | 177 |
| | | female | 439 | 421 | 404 | 376 | 359 | 341 | 324 | 304 | 287 | 269 | 252 | 234 | 217 | 199 | 182 |

Table 2

| *bpm [t/min]* | | | *<60* | *60 - 99* | *>100* |
|---|---|---|---|---|---|
| QTcH [ms] | Upper limit | male | 465 | 452 | 450 |
| | | female | 470 | 459 | 542 |
| | Lower limit | male | 369 | 369 | 369 |
| | | female | 386 | 376 | 374 |

*Luo, Shen, Kurt Michler, Paul Johnston, and Peter W. MacFarlane. 2004. "A Comparison of Commonly Used QT Correction Formulae: The Effect of Heart Rate on the QTc of Normal ECGs." Journal of Electrocardiology 37 (SUPPL.): 81–90. https://doi.org/10.1016/j.jelectrocard.2004.08.030.*

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