King Saud University

College of Engineering

IE – 341: “Human Factors Engineering”

Spring – 2024 (2nd Sem. 1445H)

Visual Displays of Dynamic Information (Chapter 5) – part 1: Quantitative Visual Displays

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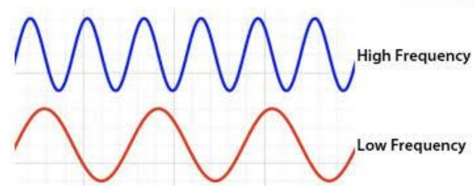
Lesson Overview

- Uses of Dynamic Information
- Quantitative Visual Displays (part 1)
- Qualitative Visual Displays (part 2)

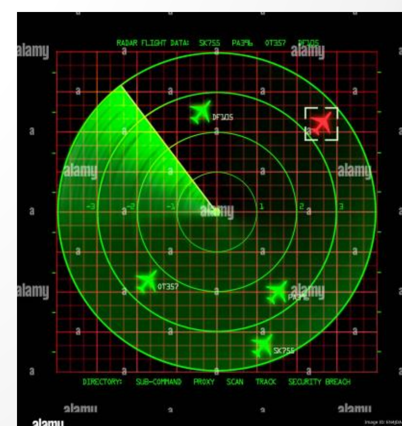
Uses of Dynamic Information

- Dynamic information: i.e. changing info; e.g:
  - natural phenomena (e.g. temperature, pressure)
  - vehicle speed
  - traffic lights
  - frequency, intensity of sounds, etc.



- Dynamic displays:
  - displays used to display dynamic information
  - types of dynamic displays, type of info. presented:

    - **Quantitative**: precise numeric value of some variable (e.g. “pressure is 80 psi”)
    - **Qualitative**: approximate value/rate of change/change in direction (e.g. “pressure is increasing”)
    - **Status**/check: determines if readings are normal (e.g. “pressure is normal”)
    - **Representational**: situation awareness; e.g. radar display predicts where plane will be in 5 or 10 minutes

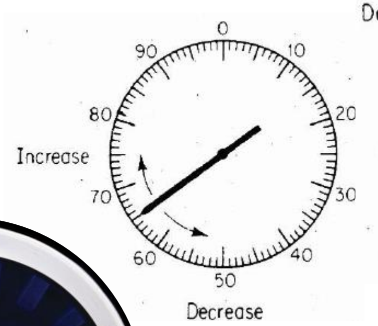


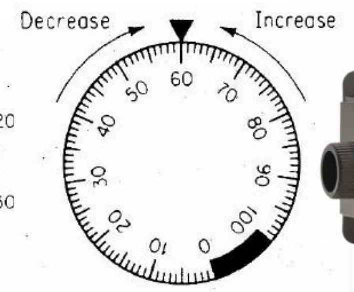
Quantitative Visual Displays

Quantitative Visual Displays

- Types of variables in QVD's:
  - changing/dynamic variables (e.g. temp., pressure)
  - static variables (rare): length, weight of objects

- Basic Design of Quantitative Displays
  - **Mechanical displays** (see next slide)
    - fixed scale with moving pointer (analog): a-e
    - moving scale with fixed pointer (analog): f-i
    - digital display: j

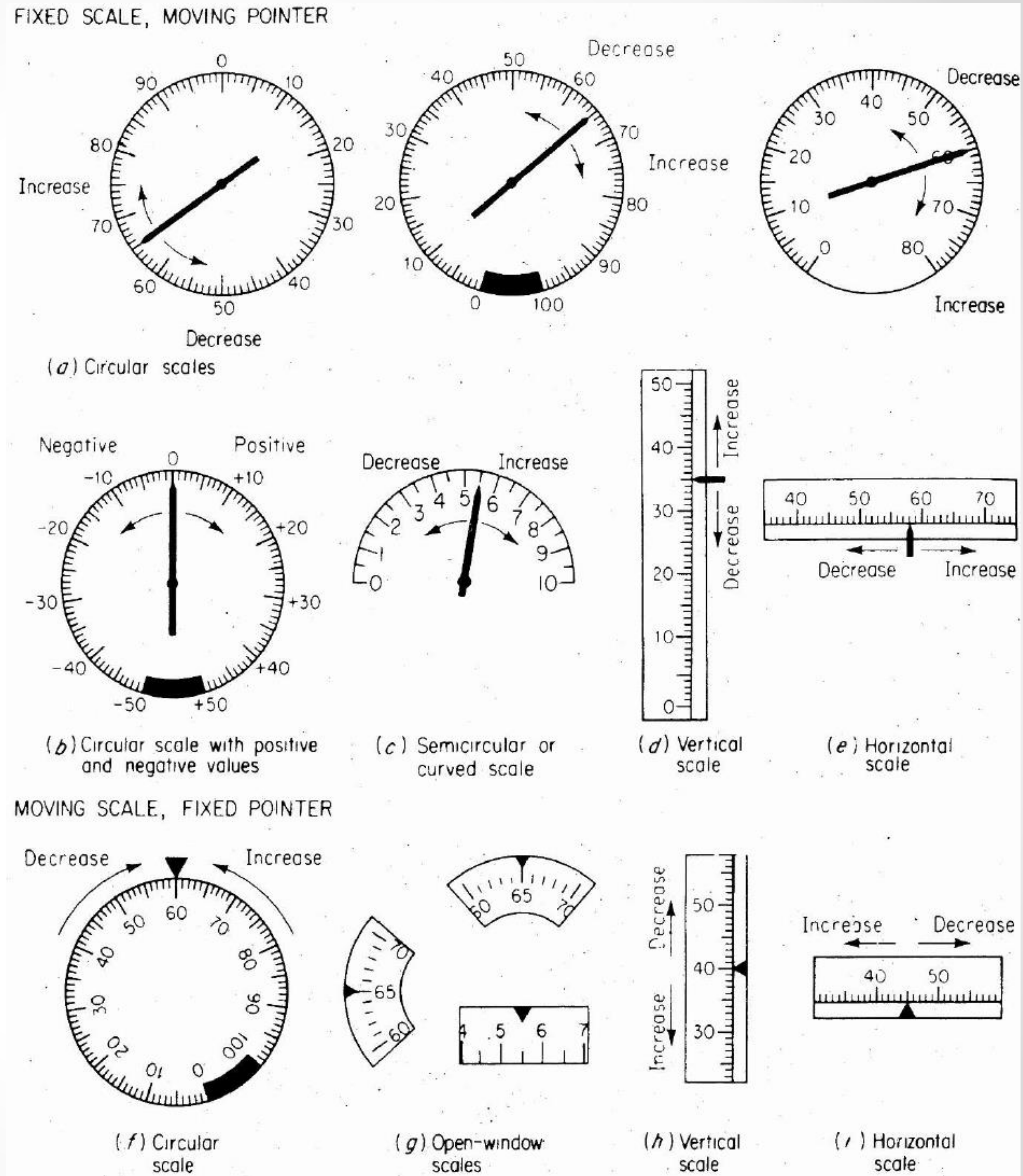




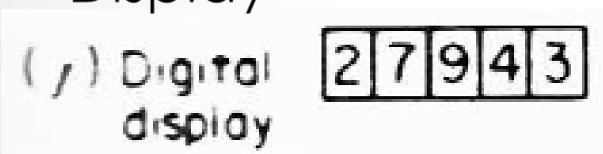
  - **Electronic displays** (see slide 7)
    - analog scales: k,l
    - digital scale: m

Mechanical Displays

1. Analog Displays

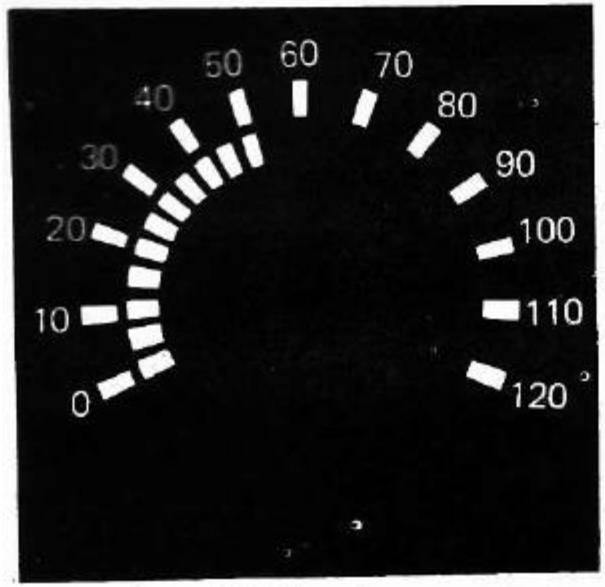


2. Digital Display

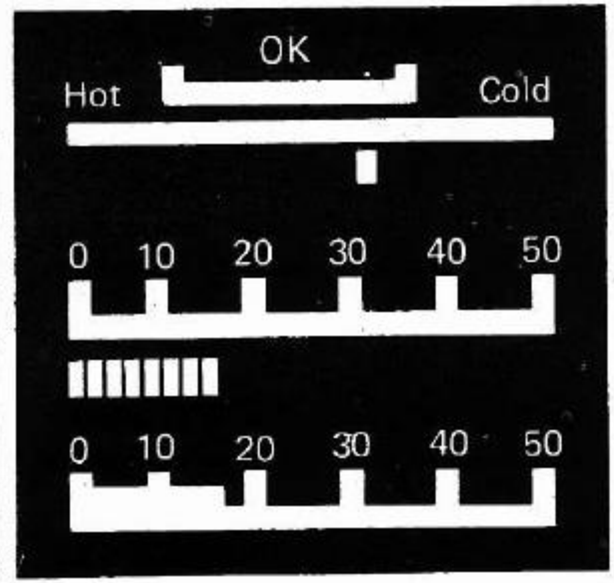


Electronic Displays

1. Analog Displays

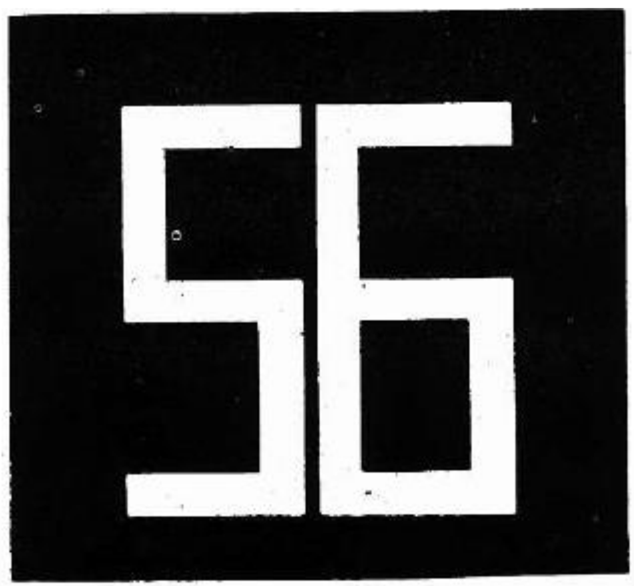


(*k*) Circular



(*l*) Horizontal

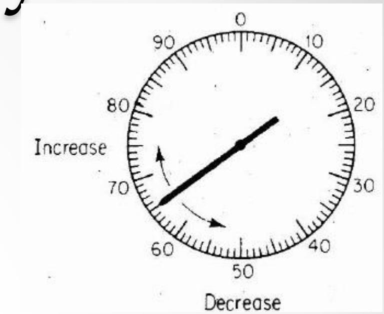
2. Digital Display



(*m*) Digital

Cont. Quantitative Visual Displays

Comparison of Different Designs (Studies)



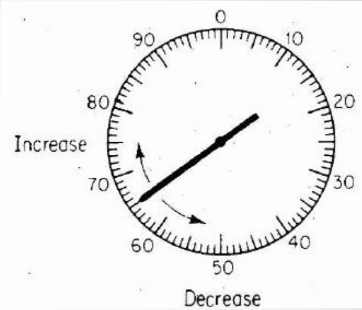
- Digital displays preferred vs. analog when:
    1. a precise numeric (quantitative) value is required
    2. values shown remain visible long enough to be read (i.e. not continuously changing)

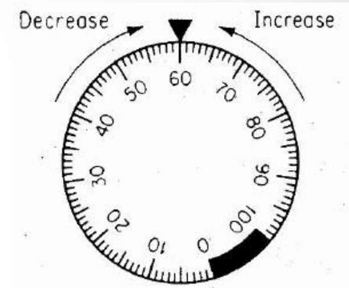
- Analog displays preferred vs. digital when:
    - o fixed-scale moving-pointer displays: useful when the values change frequently/continuously ⇒ limited time in reading values if digital displays were used
    - o when important to know direction or rate of value change (qualitative reading)

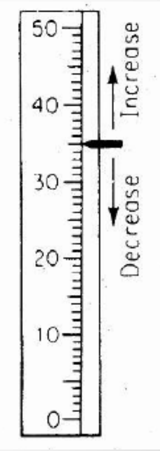
Cont. Quantitative Visual Displays

Cont. Comparison of Different Designs

- Fixed scale w/ moving pointer vs.
  moving scale w/ fixed pointer



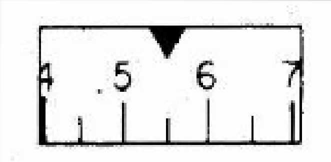




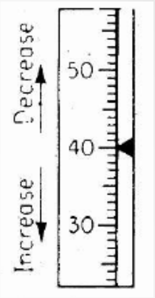
1. generally: fixed scale is preferred vs. moving scale
2. if numerical increase is related to another natural interpretation (e.g. more or less, up and down):
   - easier to interpret straight line (horizontal or vertical scales) or thermometer scale with a moving pointer
   - pointer position relative to zero/null adds value
3. don't mix different types of pointer-scale indicators when used for related functions
   - this avoids reversal errors in reading
4. direction of motion of moving element is clearer if manual control moves pointer (rather than scale)
5. for slight variable movements/changes in quantity ⇒ more clear if a moving pointer is used

Cont. Quantitative Visual Displays

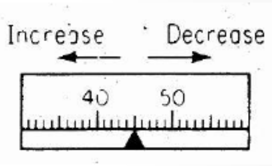
Cont. Comparison of Different Designs



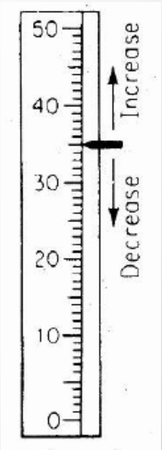
- Moving scale w/ fixed pointer vs.
  fixed scale w/ moving pointer

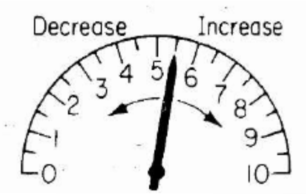


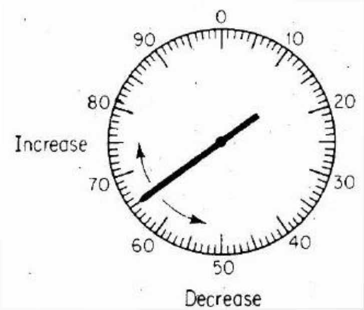
1. moving scale preferred (due to small panel space) when range of values: too great to show on small scale; e.g.:
   - moving rectangular open-window scales
   - moving horizontal and vertical scales
2. also when a numerical value is needed to be readily available, a moving scale appearing in an open window can be read more quickly



- Circular/Semicircular scales vs. vertical/horizontal
  - o circular/semicirc. scales generally preferred (a,b,c)
  - o vertical/horizontal preferred (d,e) when relating to null or viewing more/less, up/down



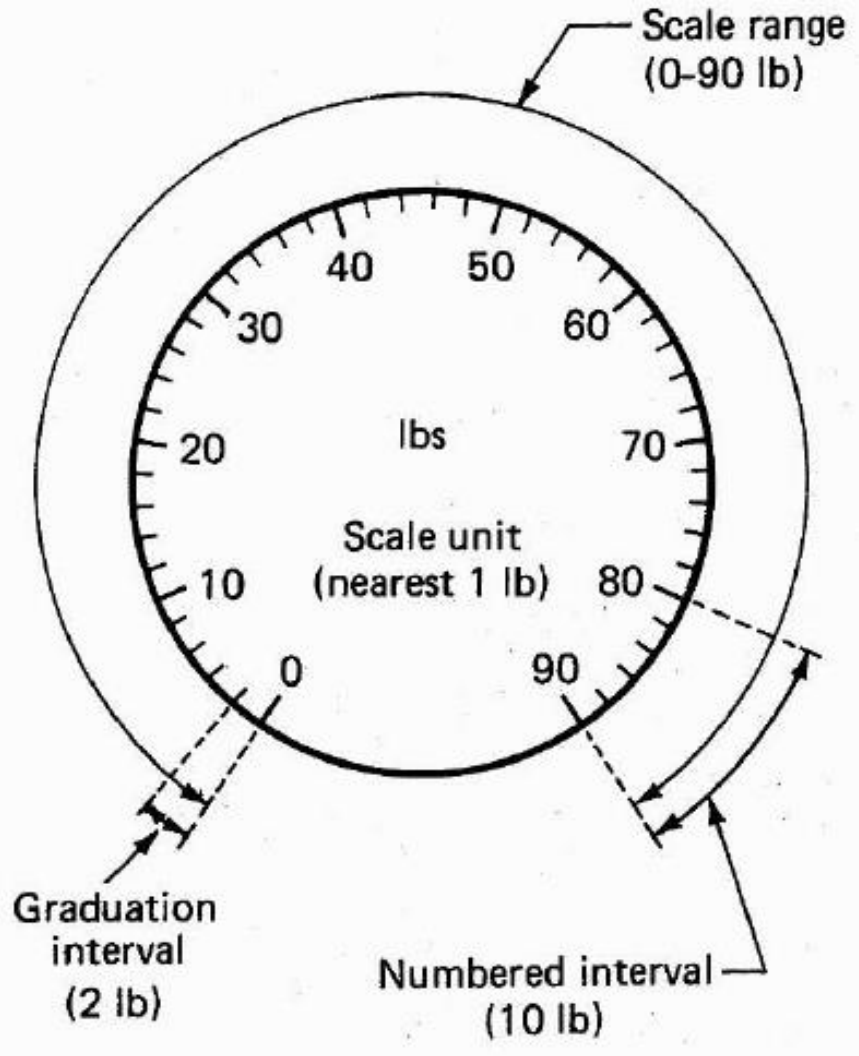




Cont. Quantitative Visual Displays:

Basic Features of Quantitative Displays

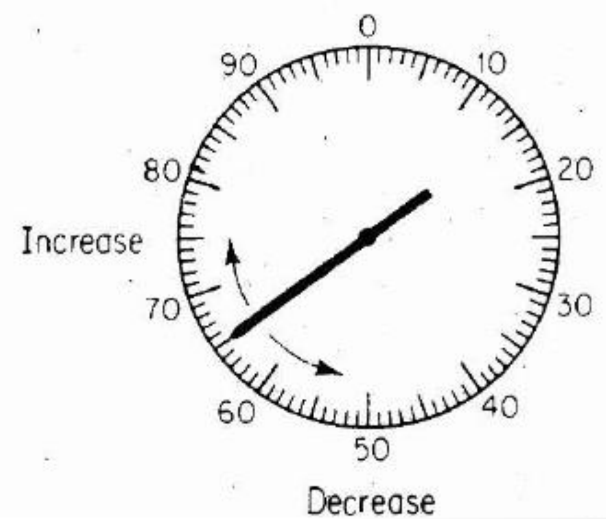
- Scale range:
  - numerical difference bet. highest & lowest values on scale
- Numbered interval:
  - numerical difference bet. adjacent #'s on scale
- Graduation interval:
  - numerical difference bet. smallest scale markers
- Scale unit
  - smallest unit to which scale is to be read (note, not necessarily = graduation interval)



Cont. Quantitative Visual Displays

Specific Features of Conventional Quant. Displays

- Ability of people to make visual discriminations in QVD's is influenced by the following specific features:
  1. **Numeric Progressions of Scales**
  2. **Length of Scale Unit**
  3. **Design of Scale Markers**
  4. **Scale Markers and Interpolation**
  5. **Design of Pointers**
  6. **Combining Scale Features**
  7. **Scale Size and Viewing Distance**



- Note, above features discussed here for mechanical scales, yet much of this applies also to electronic displays

Cont. Quantitative Visual Displays

Specific Features of Conventional Quant. Displays

1. **Numeric Progressions of Scales**

- Every quantitative scale has numeric progression system, including
  - o graduation interval: bet. adjacent markers
  - o numbered interval: major scale markers
- Number progressions:
  - o progression by 1s (0,1,2,3,…) is easiest to use (see figure on next slide):
    - major markers: 0,10,20,30,….,
    - with intermediate markers: 5,15,25,35,….,
    - with minor markers at individual numbers
  - o progression by 5 is also satisfactory
  - o progression by 25 is moderate.
- Decimals make scales more difficult to use:
  - o if used, zero before decimal should be omitted
- Unusual progressions (3s, 8s etc): avoid

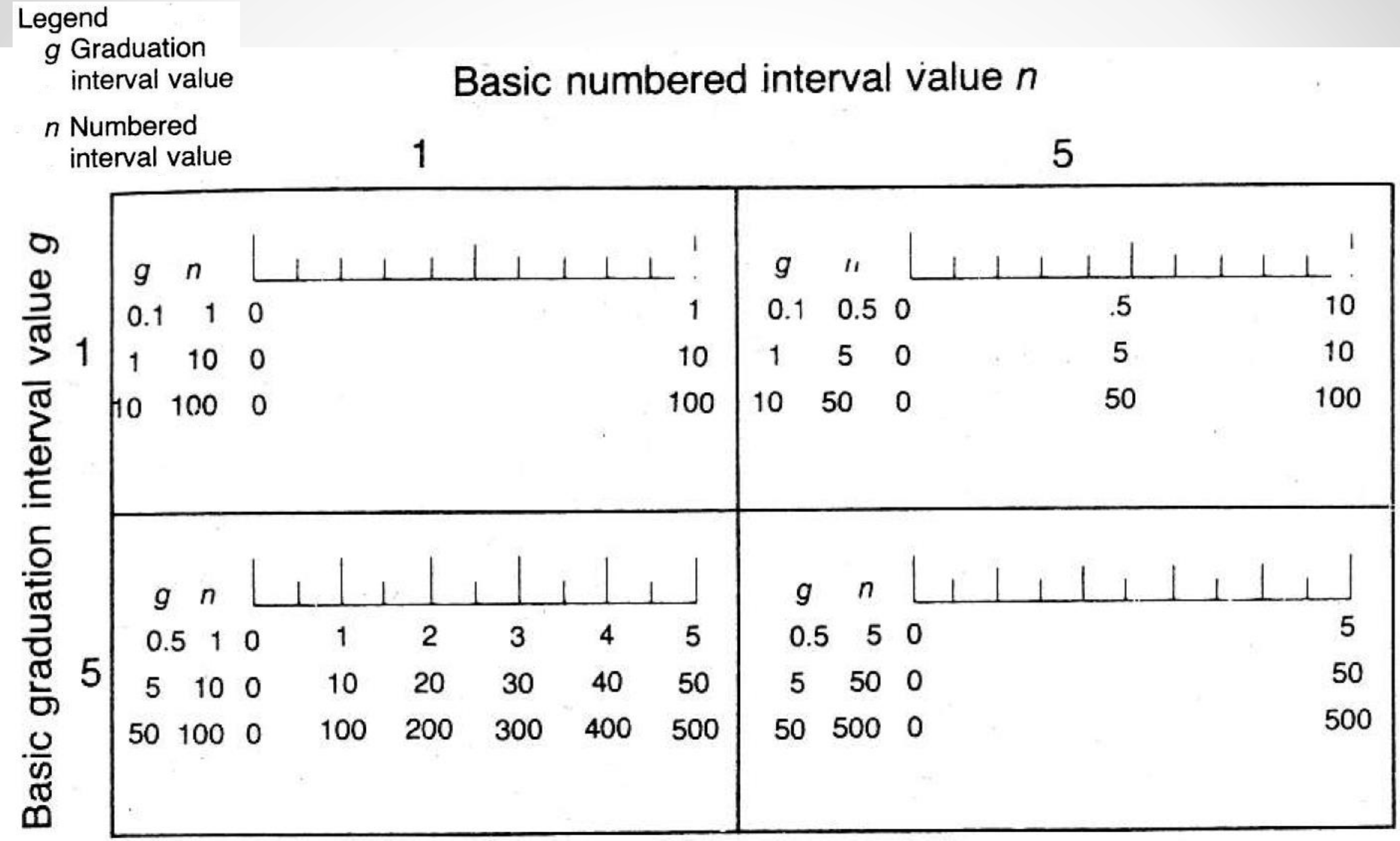


FIGURE 5-3
Examples of certain generally acceptable quantitative scales with different numeric progression systems (1s/5s). The values to the left in each case are, respectively, the graduation interval g (the difference between the minor markers) and the numbered interval n (the difference between numbered markers). For each scale there are variations of the basic values of the system, these being decimal multiples or multiples of 1 or 5.

Cont. Quantitative Visual Displays

Specific Features of Conventional Quant. Displays

2. Length of Scale Unit

- Def^n: length on scale representing smallest numeric value to which the scale is to be read
  - e.g. force is to be measured to nearest 10 Newtons,
  - on scale: 10 N is to correspond to 1.3 mm
  - ⇒ length of scale unit = 1.3 mm

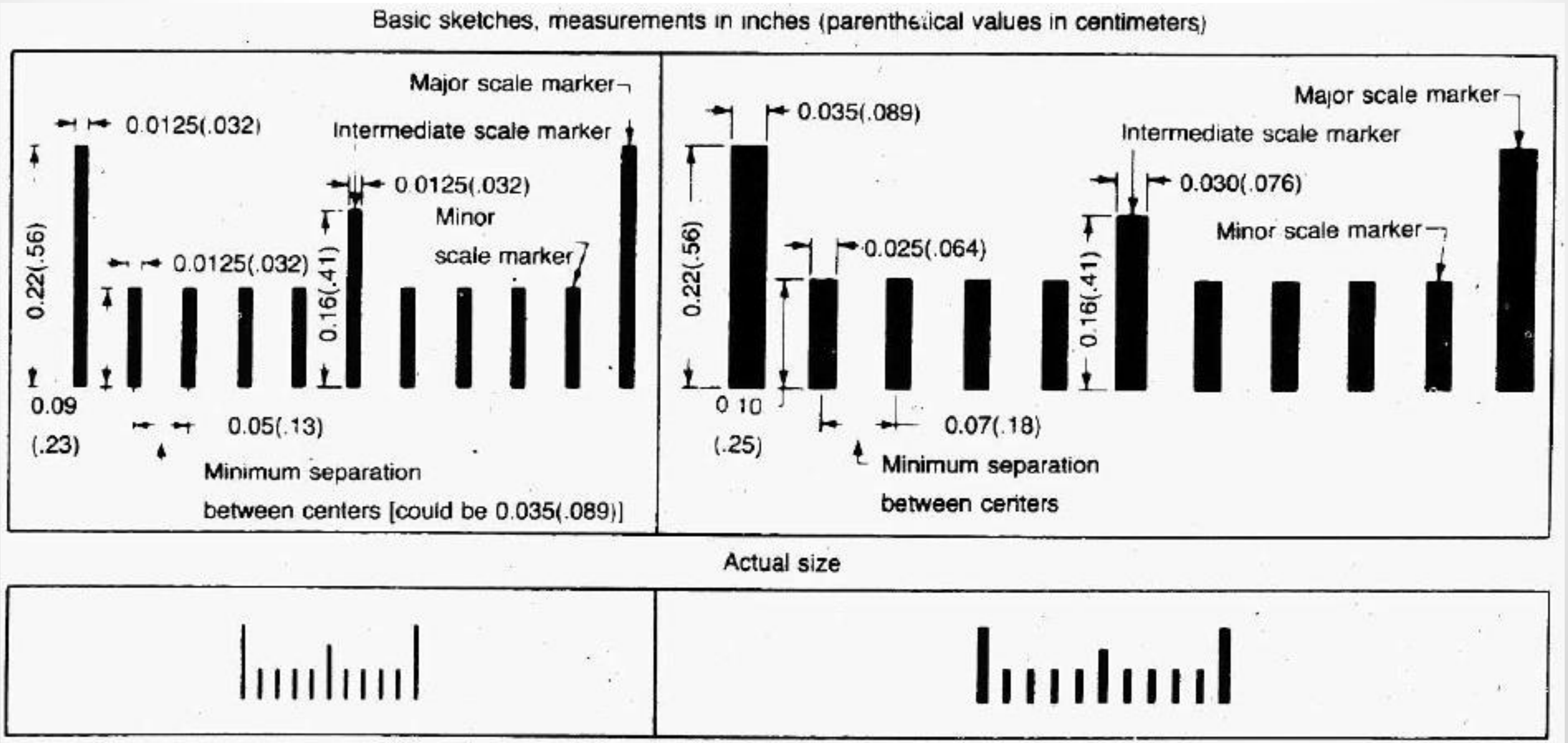
- Length of scale unit should allow distinctions between values with optimum reliability in terms of human sensory & perceptual skills:
  - research suggests values between: 1.3 - 1.8 mm
  - larger values are needed when instruments are used in non-ideal conditions
    - e.g. low vision, poor illumination, limited time, etc

Cont. Quantitative Visual Displays

Specific Features of Conventional Quant. Displays

2. Cont. Length of Scale Unit

- Recommended format for quantitative scale given length of scale unit (?), graduation markers

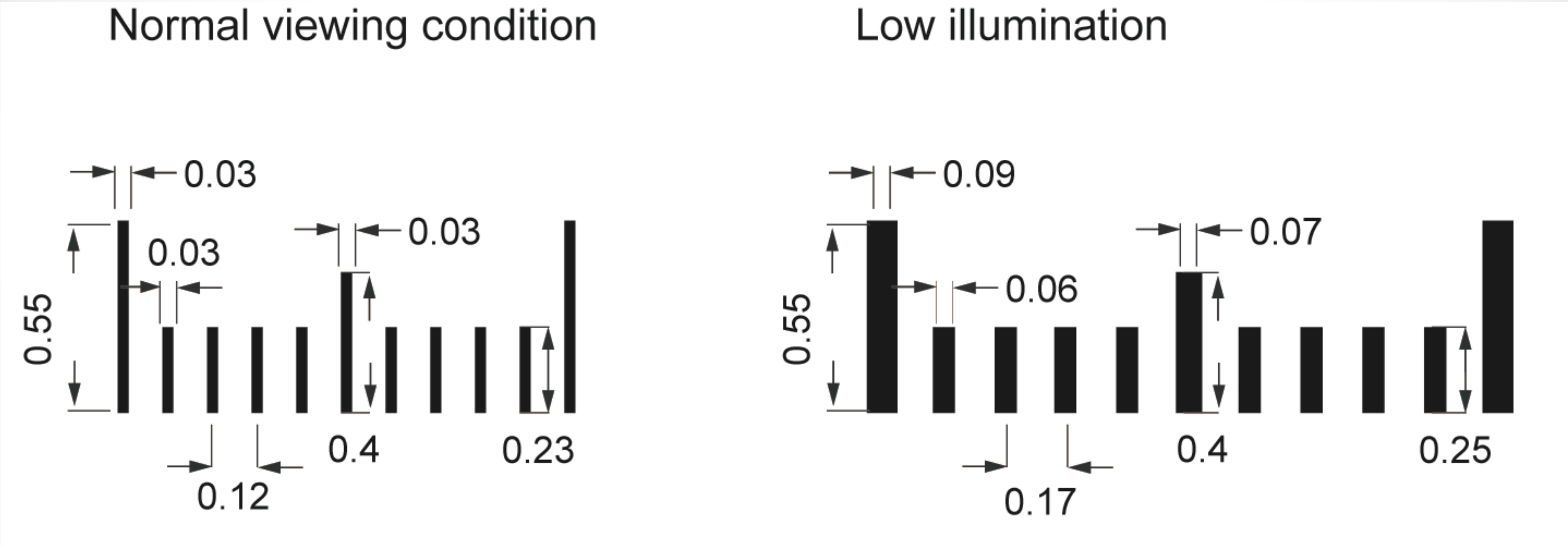


(a) Normal viewing condition (b) Low illumination

Cont. Quantitative Visual Displays

Specific Features of Conventional Quant. Displays

2. Cont. Length of Scale Unit

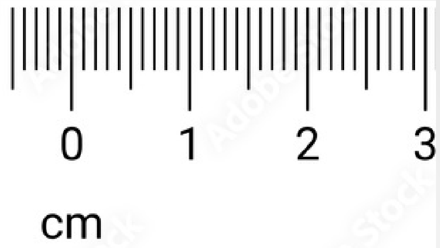


Source: Jörgen, Carl. "Assessment of Automotive Visual Display Guidelines and Principles: A Literature Review" (2011). *The Design Journal* 14(4):446-474.

Cont. Quantitative Visual Displays

Specific Features of Conventional Quant. Displays

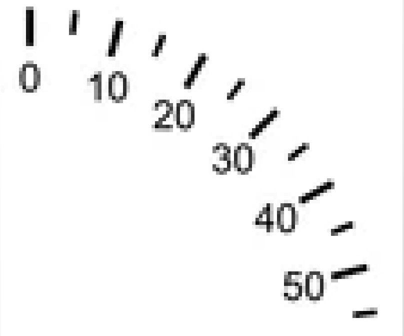
3. Design of Scale Markers



- Recommended to include a scale marker for each scale unit to be read
- Conventional progression scheme, based on:
  - major markers: 1, 10, 100, etc.
  - minor markers: 0.1, 1, 10, etc.

4. Scale Markers and Interpolation

- If scales: much compressed (>last slide) ⇒ scale markers: crowded ⇒ reading accuracy decreases
  - Such case: use a scale requiring interpolation
  - **Interpolation**: *estimation* of values between markers
- For high accuracy reading of scale:
  - marker should be placed at every scale unit
  - requires: a larger scale or a closer viewing distance

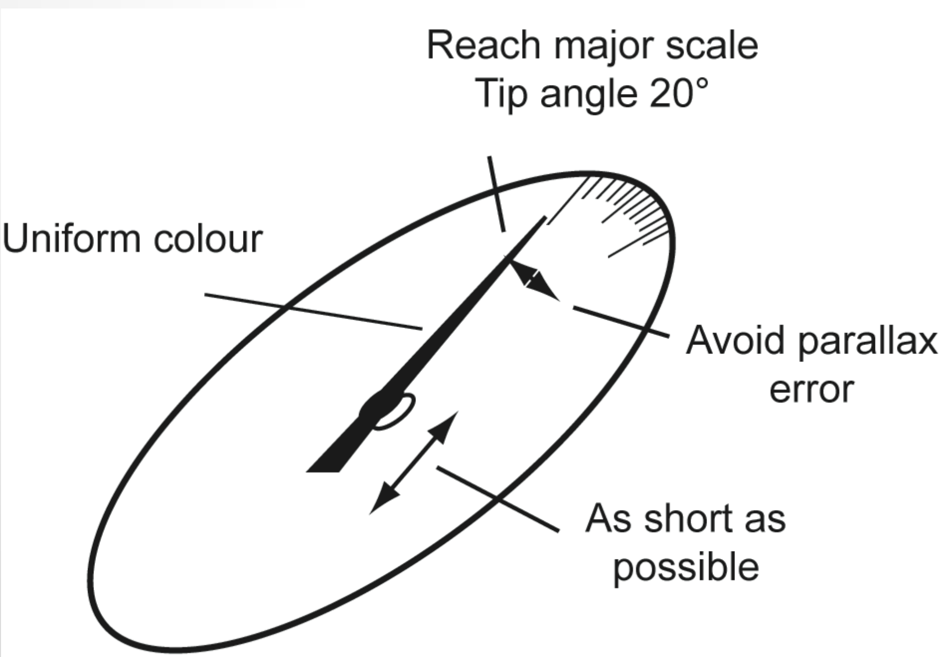


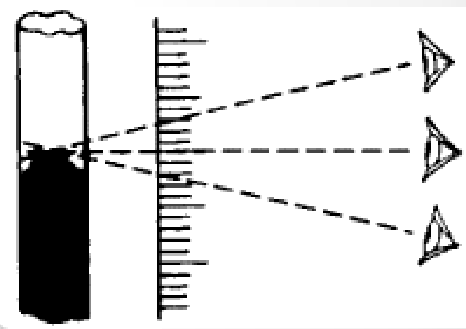
Cont. Quantitative Visual Displays

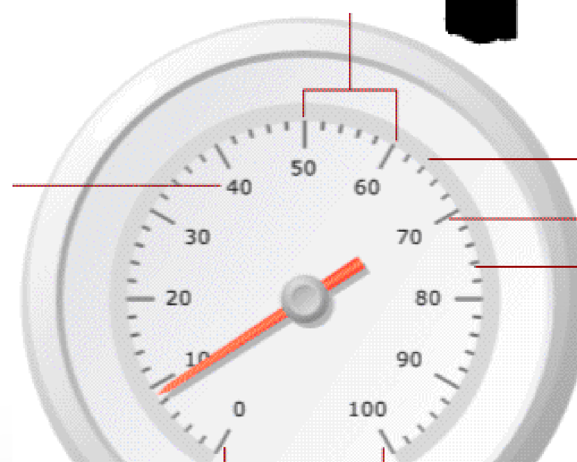
Specific Features of Conventional Quant. Displays

5. Design of Pointers

- Recommendations for pointer design:
  - pointed pointers (tip angle of about 20°)
  - have the pointer tip meet, but not overlap, the smallest scale markers
  - have the color of the pointer extend from the tip to the center of the scale
  - have the pointer close to the surface of the scale to avoid parallax (see below)





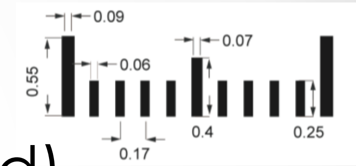


Cont. Quantitative Visual Displays

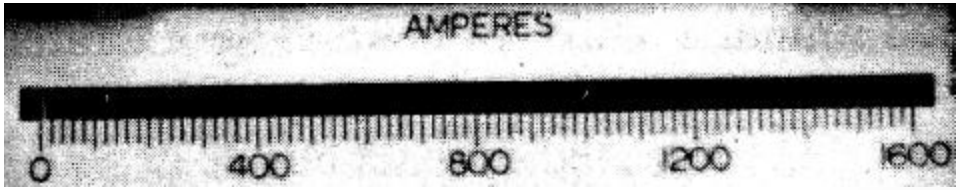
Specific Features of Conventional Quant. Displays

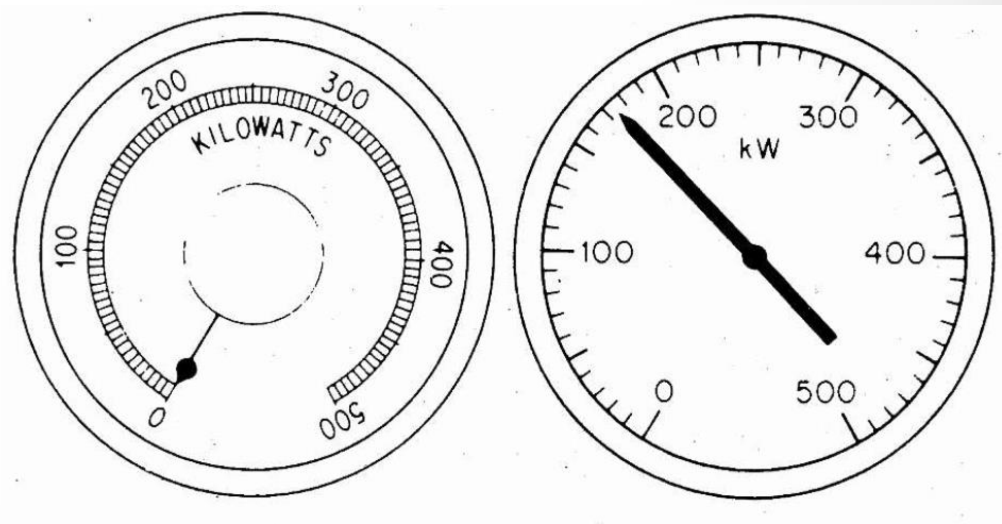
6. **Combining Scale Features**

- Mentioned features of quantitative scales: are integrated into relatively standard formats
  - e.g. slide 15: used for circular, semi-circular scales



- Note, above features: only general (non-rigid) guidelines
- e.g.'s of poor scale designs:
  - Ampere scale:
    - shortness of scale units
    - inadequate inter-mediate markers
  - Kilowatt scale (left):
    - name **5** corrections?





a. Original

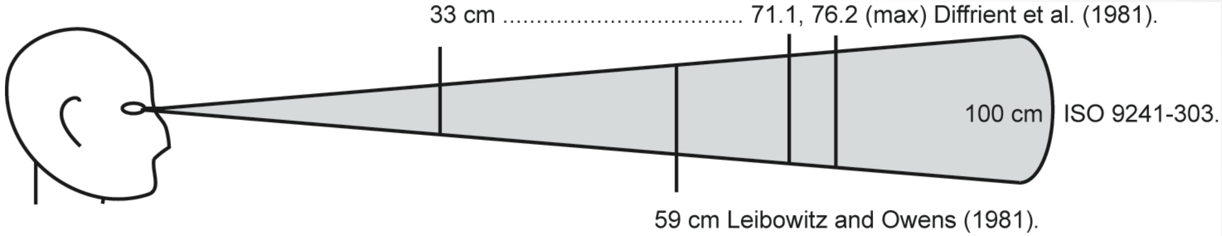
b. Redesigned

Cont. Quantitative Visual Displays

Specific Features of Conventional Quant. Displays

7. Scale Size and Viewing Distance

- previous guidelines: for normal viewing distance: 28 in. (71 cm)



- If display viewed from farther distances ⇒
  - features have to be enlarged to maintain the same visual angle (VA) at the eye

- To maintain same VA for any viewing distance x: use this formula to find proper dimension :
  - **Dimension at x [in] =**
    Dimension @ 28 in * (x [in] / 28)
  - Example: find @ 100 cm from scale (viewed in normal viewing conditions):
    - minimum length of scale unit
    - VA
    - minimum Snellen acuity required to read scale

References

- ***Human Factors in Engineering and Design***. Mark S. Sanders, Ernest J. McCormick. 7th Ed. McGraw: New York, 1993. ISBN: 0-07-112826-3.