

1. Here is an annotated version of the R code I used to produce the plot in test question sheet. There are a few subtleties in this and I didn't expect you to get every detail right.

The first step is to assign the variables needed for the plot. You were permitted to skip this, but I've added it just for completeness.

```
mon = c("Jan", "Feb", "Mar", "Apr", "May", "Jun",  
        "Jul", "Aug", "Sep", "Oct", "Nov", "Dec")  
temp = c(3.9, 4.4, 6.7, 8.9, 12.2, 15.6, 17.8,  
         17.2, 15, 10.6, 6.7, 4.4)
```

Now we need to set up the plot region. The "grid" of the plot extends out to a radius of 20 so, to allow some space for labels, I'll set the radius for the entire plot to 25. We don't need margins so I'll make them all small (zero doesn't work).

```
plot.new()  
par(mar = rep(0.1, 4))  
plot.window(xlim = c(-25, 25), ylim = c(-25, 25),  
            asp = 1)
```

Next we need to draw the polygon which represents the data. To do this we need to construct rays going out at 12 equally spaced angles and we make the length of the rays equal to the corresponding monthly temperature.

```
theta = seq(0, length = 12, by = 2 * pi/12)  
x = temp * cos(theta)  
y = temp * sin(theta)  
polygon(x, y, col = "lightgray")
```

Now we draw a grid over the polygon. The grid consists of two parts. The first is a set of dotted rays which go from 0 out to a radius of 20. We can reuse the x and y defined above to draw them.

```
segments(0, 0, 20 * cos(theta), 20 * sin(theta),  
        lty = "dotted")
```

The second part of the grid consists of dotted concentric (almost) circles at radii of 5, 10, and 15. We also draw a solid circle for the outside border of the plot. I've chosen to draw these circles from 3° to 357° so they don't obscure the labels.

```

segments(0, 0, 20 * cos(theta), 20 * sin(theta),
        lty = "dotted")
phi = seq(3, 360 - 3, length = 72) * (pi/180)
for (r in c(5, 10, 15)) lines(r * cos(phi), r *
        sin(phi), lty = "dotted")
lines(20 * cos(phi), 20 * sin(phi))

```

All that remains is to draw the plot labels. We draw the month abbreviations as with the statement

```
text(24 * cos(theta), 23 * sin(theta), mon)
```

and the the grid labels as follows

```
labs = seq(5, 20, by = 5)
text(labs, rep(0, length(labs)), labs)
```

That's all there is to it :-).

2. (a) Three illusions and their effects are as follows:
  - (i) The irradiation illusion results from the fact that areas appear to be larger when they are rendered in light colours than when they are rendered in dark ones. This means that we must be careful with our use of colour when we are using areas to represent values.
  - (ii) The Poggendorff illusion shows that we overestimate acute angles and underestimate obtuse ones. This means that angles should not be used to represent numerical values in plots. In particular, pie charts can really distort data.
  - (iii) We see perspective illusions when two dimensional pictures contain structures which can be interpreted as showing three dimensional perspective. This can lead to misjudgments of size. We need to be very careful that two dimensional data graphs do not contain false perspective hints.
- (b) In the plot of the right we are able to compare the lengths of the dark portions of the bars by comparing the lengths of the white portions of the bars. The absolute difference in the lengths of the white portions is the same as the absolute difference of the dark portions, but the relative difference is much greater. Weber's law says that we are much more likely to see a difference in the white portions.
- (c) The Cleveland-McGill ranking is as follows (best to worst).
  - position along a common scale
  - position along identical, nonaligned scales
  - length
  - angle, slope

- area
  - volume
  - colour hue, colour saturation, density
- (d) The lengths of rays having a common origin but different directions (as in question 1) does not appear in the Cleveland McGill ranking. I would expect it to appear between position common unaligned (but parallel) scales and length. It is very similar to the first of these because they differ only in orientation. It is likely to be better than length because of the common origin.
3. (a) When light hits the retina it is received by red, green and blue sensitive cone cells. At this point of the visual pathway the representation is RGB. The eye and its associated neural circuitry transform the visual signal into a form suitable for transmission to the visual cortex. This form is an opponent red/green, yellow/blue and luminance form. Finally, when the signal reaches the visual cortex and the higher centres of the brain, it is converted into some form of hue, saturation, brightness representation.
- (b) (i) It is through luminance differences that we detect the basic structure in scenes and images. To make clear graphs, we need to ensure that the structure is clearly indicated by differences in luminance levels. The printers saying “first get it right in black and white” echos this. (ii) Because differences in luminance produce irradiation illusions it is important to use colours of near-equal luminance when using areas to represent numerical values.
- (c) The CIELUV space is perceptually uniform. In other words the distance between points in CIELUV is a good indicator of how different two colours will appear. This makes the space useful in choosing colour schemes. For example, it is easy to choose sets of colours with equal luminance.
- (d) (i) It is hard to bring red and blue into focus simultaneously because they are refracted differently by the eye’s focusing mechanism. Since graphs need to be studied carefully and at length it is not a good idea to use red and blue for elements which must be viewed together. (ii) Since structure is conveyed by differences in luminance, it is not a good idea to use similar luminance for elements which are juxtaposed. For example, it is not a good idea to draw yellow lines of points on a white background.