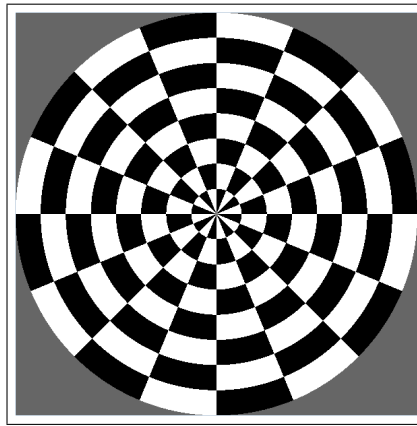


5 Further Graphics (PAB)

- (a) Write a GLSL function `dartboard()` which takes as input a texture co-ordinate `texCoord` which ranges from $(0, 0) \rightarrow (1, 1)$, and returns the colours of the procedural texture for a black-and-white dartboard pattern of 16 squares around and 8 squares in radius (see figure below). The background behind the dartboard is gray.

```
vec3 dartboard(vec2 texCoord) {
    // [YOUR CODE HERE]
}
```



[6 marks]

- (b) What is ...

(i) the formula for the *face angle* $\alpha(F, v_i)$ of face F at vertex v_i of a closed manifold? [2 marks]

(ii) the formula for the *angle deficit* $AD(v)$ of vertex v and its surrounding set of faces $\{F\}$? [2 marks]

(iii) the formula for the *Poincaré Formula* of a surface with genus g and Euler characteristic χ ? [2 marks]

(iv) the formula for *Descartes' Theorem of Total Angle Deficit*? [2 marks]

- (c) Consider a closed manifold surface with total angle deficit -4π .

(i) If your hypothetical surface has 20 vertices and 20 faces then how many edges must it have? [2 marks]

(ii) Sketch a picture of your surface. [4 marks]