4 Further Graphics (PAB)

(a) Here are two methods for implementing a cube using signed distance fields:

```c
float methodOne(vec3 p) {
    return max(max(abs(p.x), abs(p.y)), abs(p.z)) - 1;
}

float methodTwo(vec3 p) {
    vec3 d = abs(p) - vec3(1);
    return min(max(d.x, max(d.y, d.z)), 0.0)
        + length(max(d, 0.0));
}
```

One is preferable to the other for producing better images faster. Which one, and why? [4 marks]

(b) Complete the code below to implement the signed distance field function for a finite line segment with hemispherical end-caps (Figure 1) of arbitrary start point, end point, and radius. [4 marks]

```c
float lineSegment(vec3 p, vec3 start, vec3 end, float radius) {
    // [YOUR CODE HERE]
}
```

```c
float getSdf(vec3 p) {
    return lineSegment(p, vec3(-PI, 0, 0), vec3(PI, 0, 0), 0.5);
}
```

(c) Implement a version of `getSdf()` that doubles the height of your line segment and translates it by 
\(-0.5\) along the Z axis, to be centred at \((0, 0, -0.5)\) (Figure 2). [4 marks]

(d) Implement a version of `getSdf()` that warps the original line segment into a sine wave \(\sin(X)\) (Figure 3). [4 marks]

(e) Modify `getSdf()` to render the sine wave model subtracted from the taller model (Figure 4). [4 marks]
Figure 1: A finite cylinder of radius 0.5 centred at (0, 0, 0) with hemispherical end-caps, starting at (−π, 0, 0) and ending at (π, 0, 0).

Figure 2: The original finite cylinder has been enlarged to double its height on the Y axis and has been translated in Z so that it is now centred at (0, 0, −0.5).

Figure 3: The original finite cylinder has been warped with a sine wave. Its centre remains at (0, 0, 0) and its endpoints remain centred around (+/−π, 0, 0), but in between its central axis falls to Y = −1 and rises to Y = 1.

Figure 4: The sine wave has been subtracted from the double-height cylinder.

(Note: Ground plane shown at Y = −1 for illustration purposes only)