

## 4 Further Graphics (PAB)

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

```
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]

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

```
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]

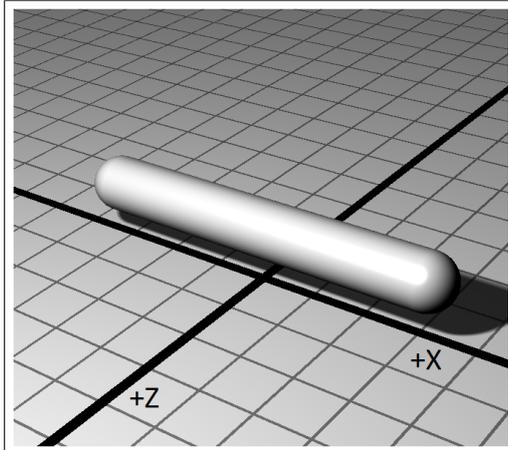


Figure 1

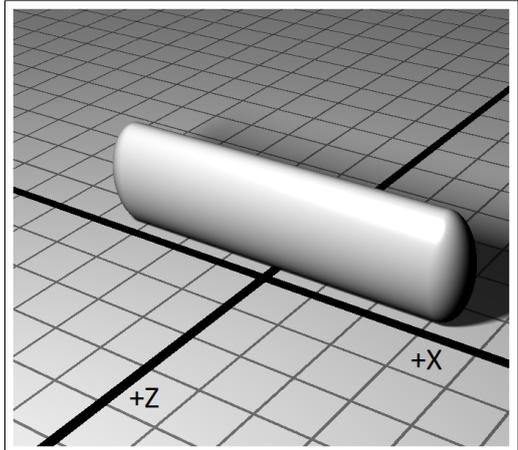


Figure 2

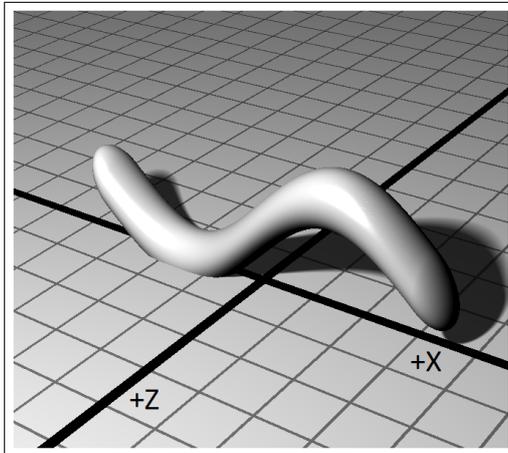


Figure 3

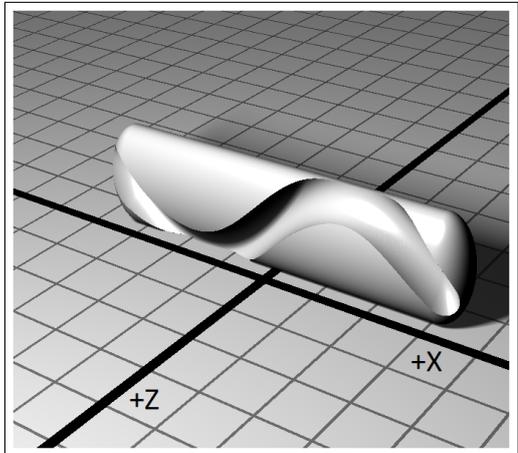


Figure 4

Figure 1: A finite cylinder of radius 0.5 centred at  $(0, 0, 0)$  with hemispherical end-caps, starting at  $(-\pi, 0, 0)$  and ending at  $(\pi, 0, 0)$ .

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  $(\pm\pi, 0, 0)$ , 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)*