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]

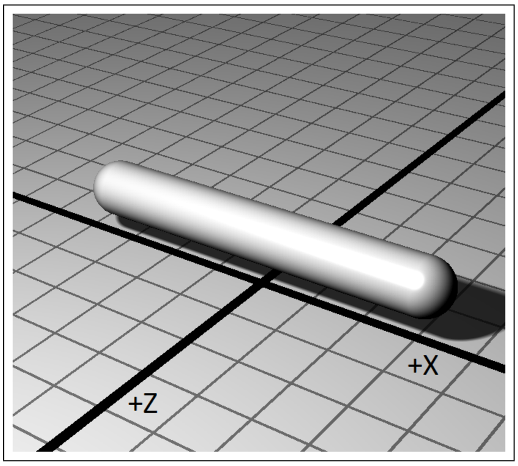

Figure 1

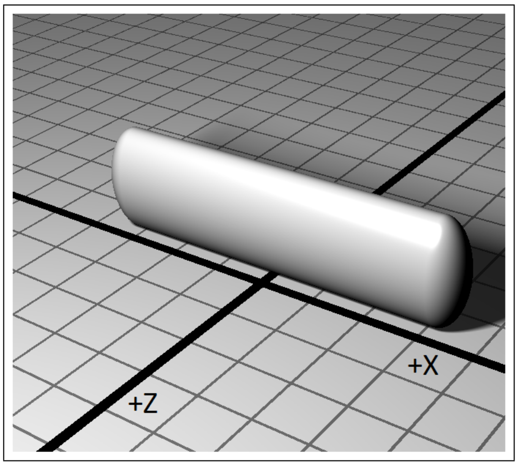

Figure 2

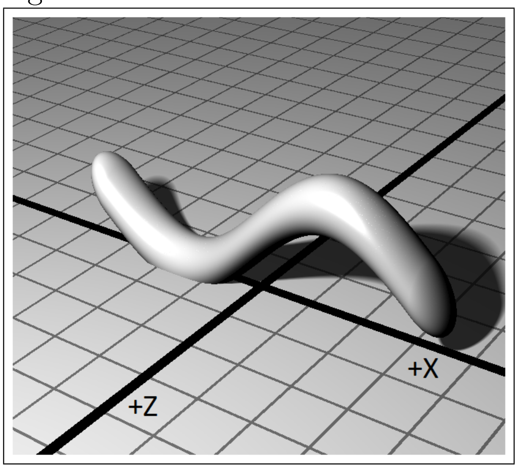

Figure 3

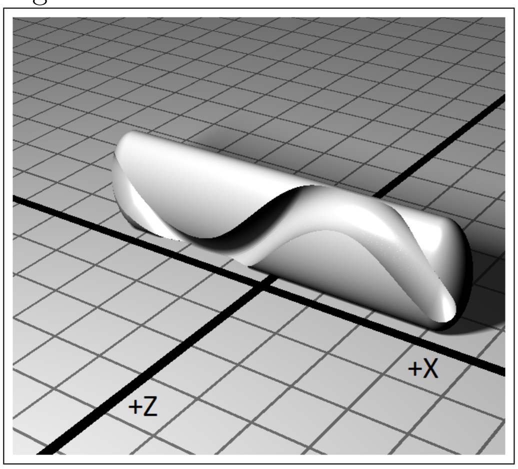

Figure 4

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 $(+/-\pi, 0, 0)$, 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)