In the following images, the edges of the shadows appear blocky. What shadow algorithm could cause these sorts of artifacts? [ /2]

What is the difference between \((x, y, z, 0)\) and \((x, y, z, 1)\) in homogeneous coordinates? [ /2]
2 Shading

2.1 Fresnel

According to Fresnel reflection, is there more light reflected when the incident illumination is at normal or grazing angle? 

What physical reason makes the Fresnel term different in metals compared to dielectrics? 

Schlick's approximation of the Fresnel term is \( R(\theta) = R_0 + (1 - R_0)(1 - \cos \theta)^5 \). What does \( R_0 \) represent (we do not ask you for a formula but for the meaning of this term)? 

2.2 Perlin noise

When using Perlin turbulence, it is advised to adapt the number of octaves of noise to the distance between the camera and the textured object. Why? Hint: the main reason is not to save CPU cycles.
2.3 Environment mapping

In this question, you will derive the steps of environment mapping. We strongly advise that you draw a figure to facilitate your derivation.

First, given the view vector $V$ and normal $N$, provide the formula for the reflection direction $R$. [

Write a test to decide which of the 6 faces of the cube is in the reflection direction. Do not worry about the case where you hit edges. [ /3]
Derive the equation for the texture coordinates in the case of the face at $x = 1$. Assume the texture coordinates $u, v$ for a face of the cube are between 0 and 1. [5]
3 Graphics pipeline and Hardware

3.1 Programmability

Which stages of the graphics pipeline have become programmable?

3.2 Hardware

Why are CPUs able to run at 3GHz while a typical graphics card is limited to 600MHz?

4 Ray tracing

4.1 Ray

What is the standard parametric equation of a ray?

4.2 Quadric

What kind of 3D shape does the quadric equation $ax^2 + by^2 + cxy + d = 0$ describe?
4.3 Intersection [\textcopyright{} 8]

Derive the intersection of a ray and the above quadric. Include the appropriate test to decide if there is intersection, the value of $t$ at the intersection, and treat potential cases where multiple intersections occur.
4.4 Normal

What is the unit normal of the quadric at the intersection point?

4.5 Monte-Carlo

What is the convergence rate of Monte-Carlo integration in general? That is, how does the error (standard deviation) evolve with the number $N$ of samples?
5 Antialiasing [ /7]

What is, according to Fourier analysis, the ideal low pass filter? That is, roughly sketch the filters in the fourier and spatial domains. [ /2]

While such a filter is theoretically ideal, it has a number of practical limitations. Describe the main one. [ /2]

Does supersampling really solve the aliasing problem? Discuss. [ /3]