Practice EXAM

This is a practice exam. Were this an actual exam, you would be allowed one side of one 8.5”x11” sheet of notes and no other aids (e.g., no calculator, no cell phone, no textbook) and given 2.5 hours to complete it. It would also only have four questions.

1 The Rendering Equation

The direction form of the rendering (a.k.a. radiance) equation [Kajiya 86] is:

\[ L_0(\vec{x}, \vec{\omega}_o) = L_e(\vec{x}, \vec{\omega}_o) + \int_{S^2} L_i(\vec{x}, \vec{\omega}_i) f(\vec{x}, \vec{\omega}_i, \vec{\omega}_o) |\vec{\omega}_i \cdot \vec{n}| \partial \vec{\omega}_i \]

In the above equation, assuming SI units for all terms,

a) What is the measure of \( S^2 \)? (Include units)

b) What are the units of \( L_e \)?

c) What phenomenon does \( L_e \) model?

d) What is \( L_e(x, \omega) \) at a point \( x \) on the surface of a red rubber ball where the normal is \((0, 1, 0)\)?

e) Why is the rendering equation hard to solve analytically?

f) What are the units of \( d\omega \)?
2 C++

Three different students implement a function g as follows (the body is the same in all cases):

```cpp
int g0(Array<int> array) {
    for (int i = 1; i < array.size(); ++i) {
        array[0] += array[i];
    }
    return array[0];
}

int g1(Array<int>& array) {
    for (int i = 1; i < array.size(); ++i) {
        array[0] += array[i];
    }
    return array[0];
}

int g2(const Array<int>& array) {
    for (int i = 1; i < array.size(); ++i) {
        array[0] += array[i];
    }
    return array[0];
}
```

They then invoke their versions of g from the body of a loop that executes 100,000 times on arrays of size $n = 1$ up to $n = 1e6$. Describe what happens at compile time and at run time for each student. Which implementation is “the best”? Is there a “better” alternative to all of these?
3 Ray Intersection

Let annulus $A$ be the region between rings of radius $r$ and $s$ (where $r > s > 0$) centered at point $c$ in the plane with normal $n$. Write an algorithm that computes the distance $t$ along ray $R$ to the intersection with $A$. Let $t = \infty$ if there is no intersection exists.
4 Fur

In the *Gopher Broke* short film by Blur, the gopher character is covered in fur that comprises millions of individual hairs. Describe how you would model and render a furry character in a photon mapping ray tracer.
5 Transformations

Derive the 2D (3x3) transformation matrix $M$ such that $M \times [x \ y \ 1]^T$ is the point $(x, y)$ rotated by $\theta$ about the point $(2, 0)$ [not rotated about the origin!]. Show all work.
BSDFs

For the specified input angle measures and wavelengths in each of the following problems, sketch the bidirectional scattering distribution function for the outgoing photon direction.

"Yellow" Car Finish

"Green" Glass

"Purple Rubber"