Basic Topic or Keyword lists

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These are some topics or keywords that I found with chatgpt

For the basic concepts portion, you might cover topics such as:

A. Core Rendering Algorithms [Classical]

- Path tracing variants: bidirectional path tracing, Metropolis light transport, manifold exploration.
- Photon mapping & progressive photon mapping.
- Many-light methods: Lightcuts, Instant Radiosity.
- Spectral rendering vs RGB: dispersion, fluorescence, thin-film interference.

B. Acceleration & Efficiency [Classical]

- Importance sampling: neural path guiding, product sampling.
- Reservoir sampling and ReSTIR (spatio-temporal sample reuse).
- GPU ray tracing acceleration (BVH optimization, RT cores).
- Out-of-core rendering for large-scale scenes.

C. Materials & Appearance Models [Classical → Generative]

- Measured BSDF/BRDF datasets (MERL, Disney models).
- Advanced BSDFs: subsurface scattering, anisotropy, layered materials.
- Hair, fur, cloth, skin: scattering & shading models.
- Participating media: volumetric scattering, neural radiance caching.
- Generative material synthesis (diffusion-based text-to-material).

D. Differentiable & Inverse Rendering [Bridging Classical & ML]

- Differentiable path tracing frameworks (Mitsuba-2, Redner).
- Inverse rendering for geometry, material, lighting estimation.
- Gradient estimators: path reparameterization, unbiased vs biased methods.

- Inverse rendering with generative priors (joint estimation with diffusion models).

E. Neural Scene Representations [Generative]

- NeRFs and successors (Mip-NeRF, Instant-NGP, KiloNeRF).
- 3D Gaussian Splatting and real-time radiance fields.
- Hybrid explicit-implicit models (sparse voxel grids + neural fields).
- Dynamic/4D neural scenes (time-varying NeRFs, video-to-4D models).

F. Generative 3D & Rendering Pipelines [Generative]

- Diffusion models for 3D.
- Score Distillation Sampling (SDS) and recent improvements such as Rectified Flow, RFDS/iRFDS.
- Text-to-3D asset generation and consistency challenges.
- Generative relighting & relightable avatars.
- Monte Carlo + diffusion priors: guiding importance sampling, generative denoising.

G. Perception & Quality [Cross-disciplinary]

- Image quality metrics: beyond PSNR/SSIM, perceptual/HDR-aware metrics.
- Psychophysics: perception-driven sampling and approximation.
- Tone mapping & HDR pipeline design.
- Perception-driven generative rendering (user-study grounded).

H. Emerging Platforms & Applications [Cross-disciplinary]

- Real-time path tracing in games and VR (RTXDI, DLSS, ReSTIR GI).
- Rendering for XR: foveated rendering, perceptually optimized methods.
- Distributed/cloud rendering pipelines.
- Rendering for fabrication: appearance-preserving 3D printing.
- Biophysically-accurate rendering (medical/scientific visualization).
- Atmospheric & planetary rendering (clouds, scattering, climate).
- Neural scene representations for robotics / embodied AI.

These are topics that I suggested for undergraduate students.

For the basic concepts portion, you might cover topics such as

- Fundamentals of computer graphics: rasterization, ray tracing, rendering pipeline.
- 2D and 3D transformations: translation, rotation, scaling, and their matrix representations.
- Graphics primitives: points, lines, polygons, curves, surfaces.
- Color theory and color models: RGB, CMYK, HSL, HSV.
- Lighting and shading models: Phong, Gouraud, Lambertian.
- Texture mapping and filtering.
- Introduction to OpenGL or DirectX for graphics programming.

For the follow-up presentations, you could have topics such as:

- Advanced rendering techniques: global illumination, ambient occlusion, and physically-based rendering.
- GPU programming for graphics: CUDA, OpenCL, or WebGL.
- Virtual reality and augmented reality applications.
- Graphics in video games: optimization techniques, level design, and procedural content generation.
- Computer animation: keyframe animation, skeletal animation, and motion capture.
- Graphics hardware: GPUs architecture, parallel processing, and graphics APIs.
- Graphics in user interfaces and user experience design.

Some topics or keywords that you can start with:

- Real-time rendering techniques
- Photorealistic rendering algorithms
- GPU-based rendering architectures
- Advanced shader programming
- Virtual reality (VR) rendering challenges
- Augmented reality (AR) graphics applications
- Procedural content generation in computer graphics
- Non-photorealistic rendering (NPR) techniques
- Interactive 3D graphics applications
- Graphics APIs comparison: OpenGL vs Vulkan vs DirectX
- Ray tracing in computer graphics
- Graphics optimization techniques for mobile platforms
- Machine learning applications in computer graphics
- Graphics pipeline optimization and performance tuning
- WebGL applications and advancements
- Graphics in scientific visualization and data analysis
- Geometry processing and mesh manipulation algorithms
- Visual effects (VFX) in film and animation
- Graphics hardware advancements and future trends
- Graphics in gaming: emerging technologies and trends.

Other ones:

- Physically-based rendering (PBR)
- Global illumination algorithms: path tracing, photon mapping
- Volume rendering techniques
- GPU ray tracing and ray tracing acceleration structures
- High dynamic range imaging (HDRI)
- Multi-pass rendering and compositing
- Subdivision surfaces and tessellation
- Level of detail (LOD) techniques
- Procedural texture generation
- Fluid simulation in computer graphics
- Crowd simulation and behavior modeling
- Character animation techniques: inverse kinematics, ragdoll physics
- Light field rendering and capture
- Real-time shadow rendering algorithms
- Implicit surfaces and signed distance functions (SDFs)
- Graphics for virtual production and filmmaking
- Image-based rendering (IBR) methods
- Graphics interoperability: data exchange formats, asset pipelines
- Image processing techniques for graphics applications
- Graphics benchmarks and performance evaluation methodologies

Some of recent research topics:

- Neural rendering: Exploring the integration of deep learning techniques with traditional rendering pipelines to achieve more efficient and realistic rendering results.

- Differentiable rendering: Investigating methods to make the rendering process differentiable, enabling optimization of rendering parameters directly from image-based loss functions.
- Generative adversarial networks (GANs) in graphics: Utilizing GANs for tasks such as image synthesis, texture generation, and style transfer in graphics applications.
- Real-time ray tracing: Advancements in hardware and algorithms that enable real-time ray tracing on consumer-grade GPUs, leading to more photorealistic graphics in interactive applications.
- Interactive global illumination: Developing techniques to achieve global illumination effects in real-time or interactive scenarios, enhancing the realism of computer-generated scenes.
- Physically-based simulation: Improving the accuracy and efficiency of simulations for phenomena such as fluids, cloth, soft bodies, and deformable objects in virtual environments.
- Light field rendering and capture: Researching methods for capturing and rendering light fields to enable more immersive virtual and augmented reality experiences.
- Augmented reality graphics: Exploring new approaches to seamlessly integrate virtual objects into real-world environments, including techniques for object interaction, occlusion, and lighting consistency.
- Multi-modal rendering: Investigating methods to combine different modalities such as vision, audio, and haptics to create more engaging and immersive virtual experiences.
- Content creation tools for virtual environments: Developing intuitive and efficient tools for artists and designers to create and manipulate 3D content in virtual and augmented reality applications.