

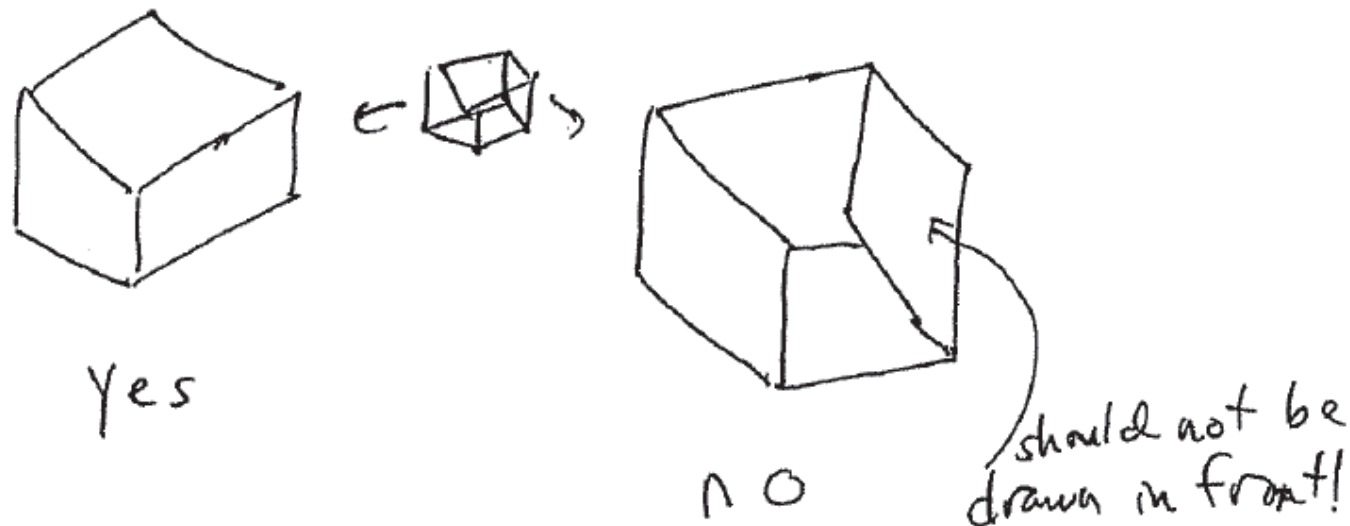
CS 428: Fall 2010

Introduction to Computer Graphics

Visibility

Visibility

- Also known as **hidden surface removal**
 - Respect the nature of occlusion in visual scenes

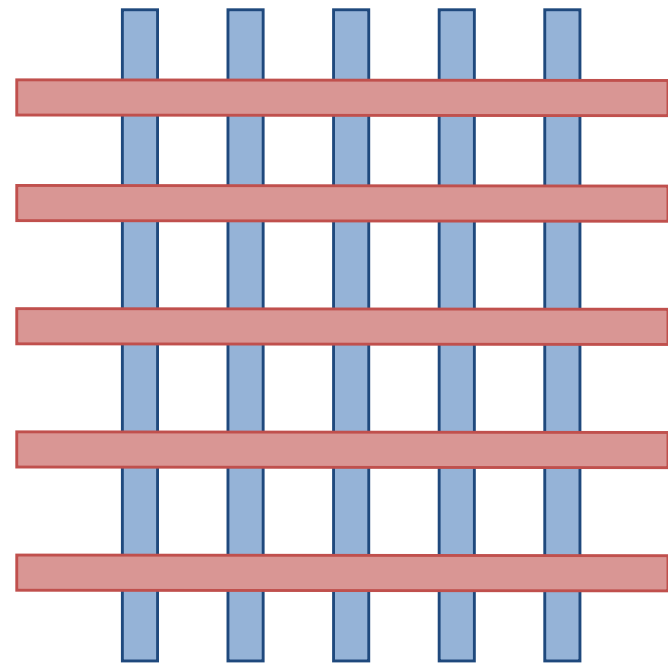


- Algorithms for determining which parts of the object/surfaces are **visible**
 - For now only **opaque** objects

Visibility algorithms

■ Complexity

- Visibility computation is comparable to sorting
- Worst case complexity is worse
- Given a scene with n polygons, there might exist $\sim n^2$ visible parts
- Worst case complexity is $O(n^2)$



Visibility

- A variety of algorithms
 - Each work better (more efficiently) in different situations
- Two main categories
 - Image precision algorithms
 - Object precision algorithms

Image precision

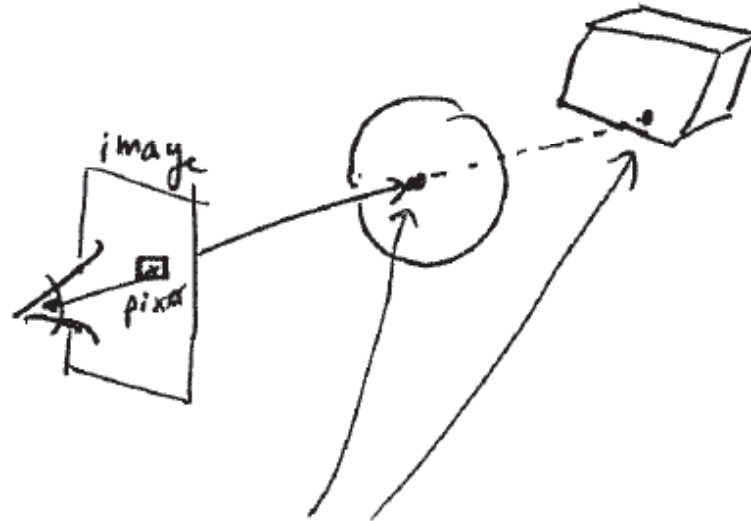
- You already know **z-buffer**
- Z-buffer algorithm is an **output sensitive** algorithm (only looks at rendered pixels)
- Brute force
 - For each pixel
 - Find object closest to camera which projects to here
 - Draw that object
- Complexity is **$O(nP)$** , while z-buffer is **$O(nP_R)$**

Image precision

- You already know **z-buffer**
- Z-buffer algorithm is an **output sensitive** algorithm (only looks at rendered pixels)
- Z-Buffer
 - Initialize depth image **D** to farthest distance
 - For each pixel **p** of each polygon with depth **d**
 - If $d(x,y) < D(x,y)$
 - Replace $D(x,y)$ with $d(x,y)$ and write color of **p** into image

Ray casting

- Review of previous lecture(s)
- Associate a ray with each pixel



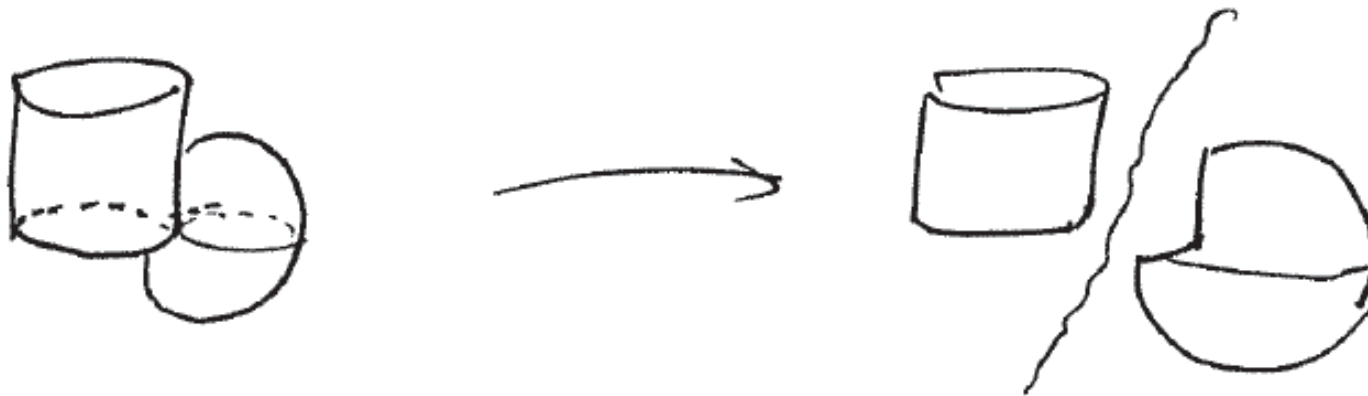
- Find object-ray intersection points
- Choose closest point to the camera

Object precision

- Operate on geometric primitives
 - For every object in the scene
 - Compute visible part (not occluded by **any** other object in the scene) → needs **high** precision
 - Draw visible part
- Results are independent of display resolution
- Brute force algorithm is **$O(n^2)$**
 - n = number of objects on screen
 - Can be improved (pre-computation) to **$O(n \log n)$**

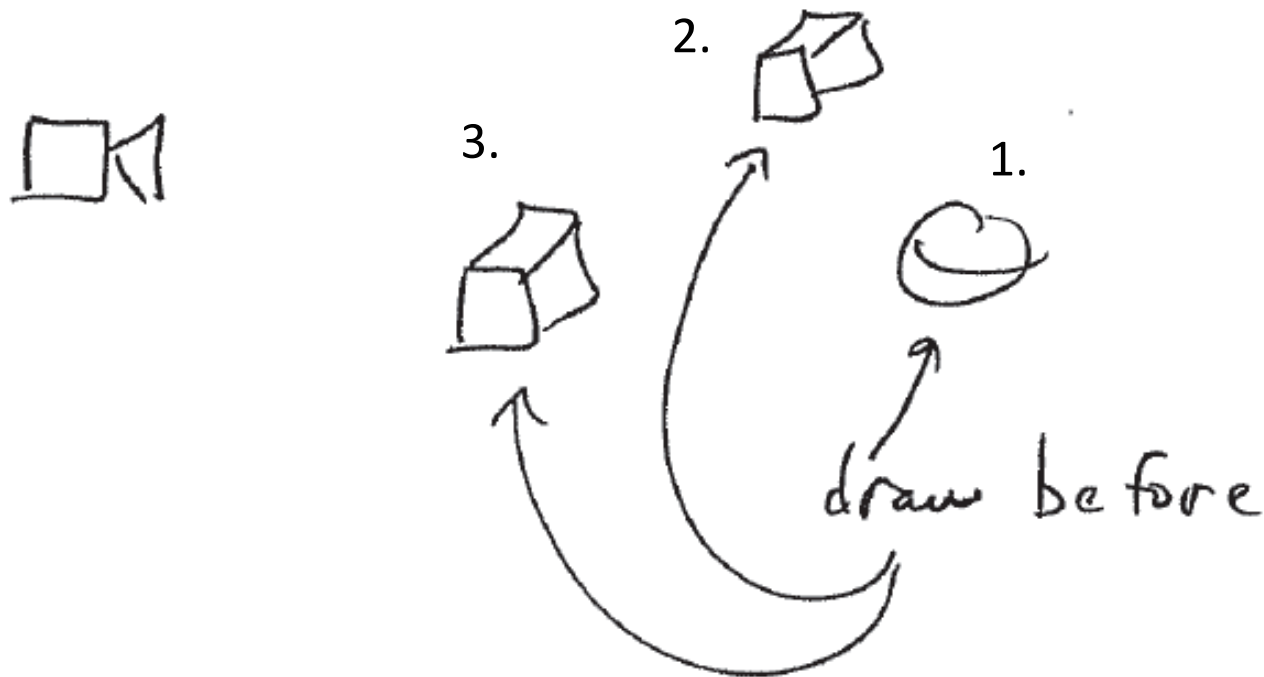
Object precision

- Hard(er) to implement
 - Due to numerical error
 - Due to tricky geometric computations (intersections, Boolean operations, etc.)

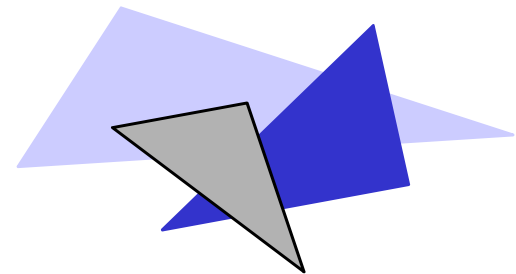


List priority methods

- Draw surfaces in **back-to-front** order



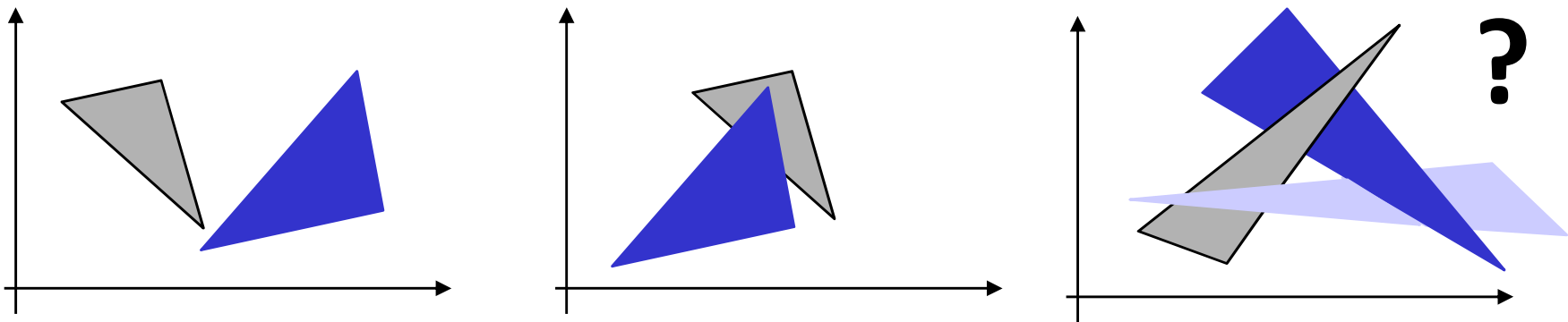
- **Painters algorithm**



List priority methods

- **Problem:**

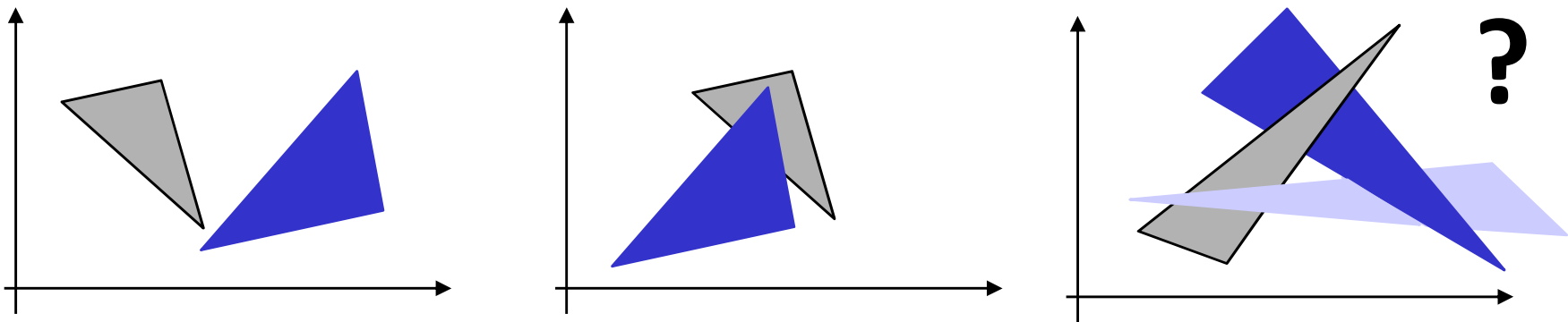
such an ordering does not always exist



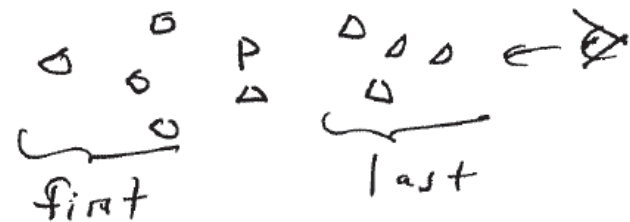
- In such cases, polygons must be **split**
- This can result in many split polygons (see worst case complexity)

List priority methods

- **Observation:**
polygons are drawn in the correct order if



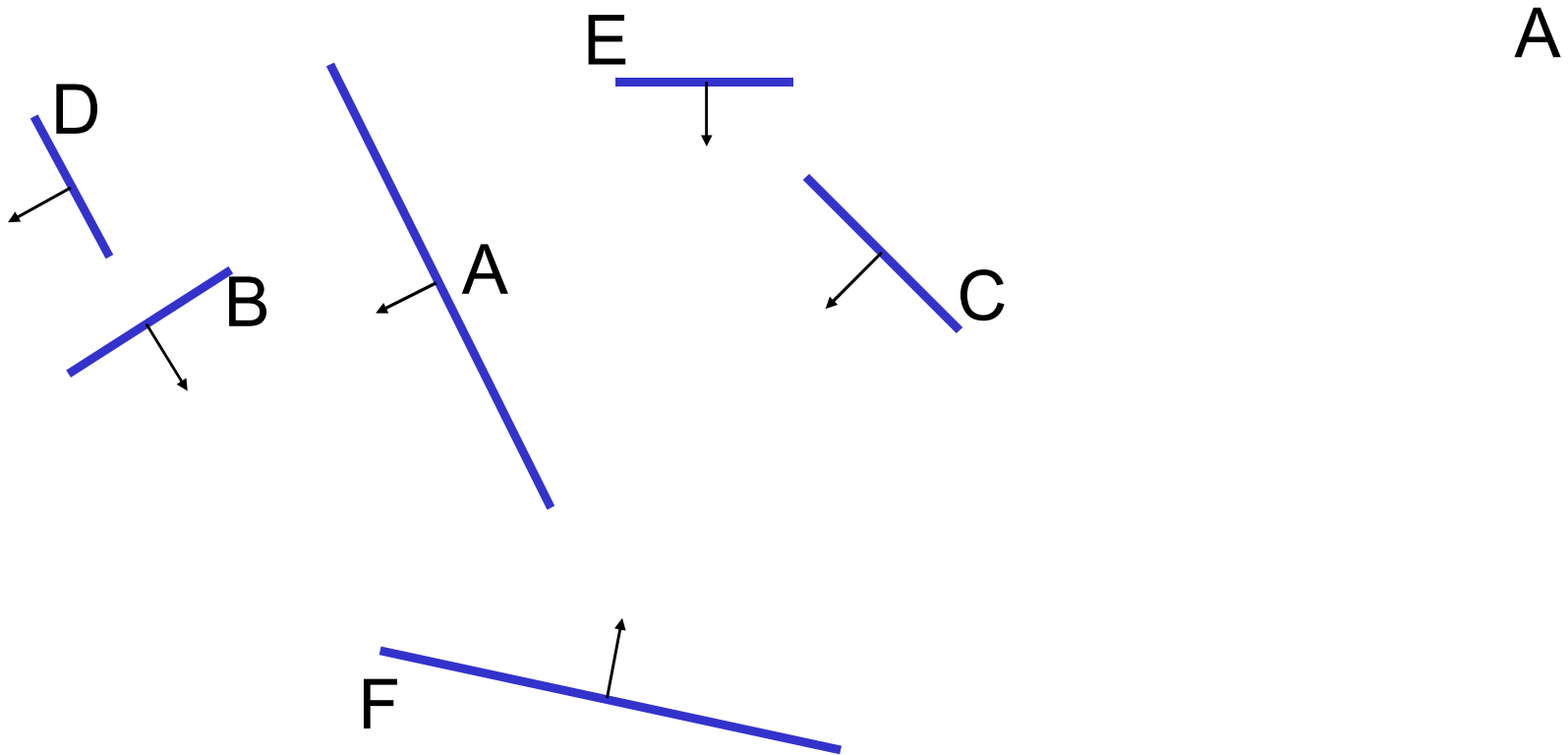
- For every polygon part **P**
 - Draw everything behind **P**
 - Draw **P**
 - Draw everything in front of **P**



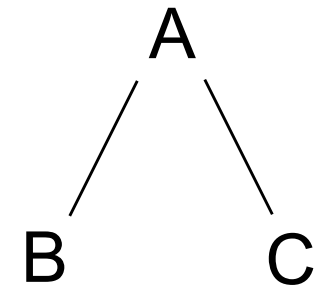
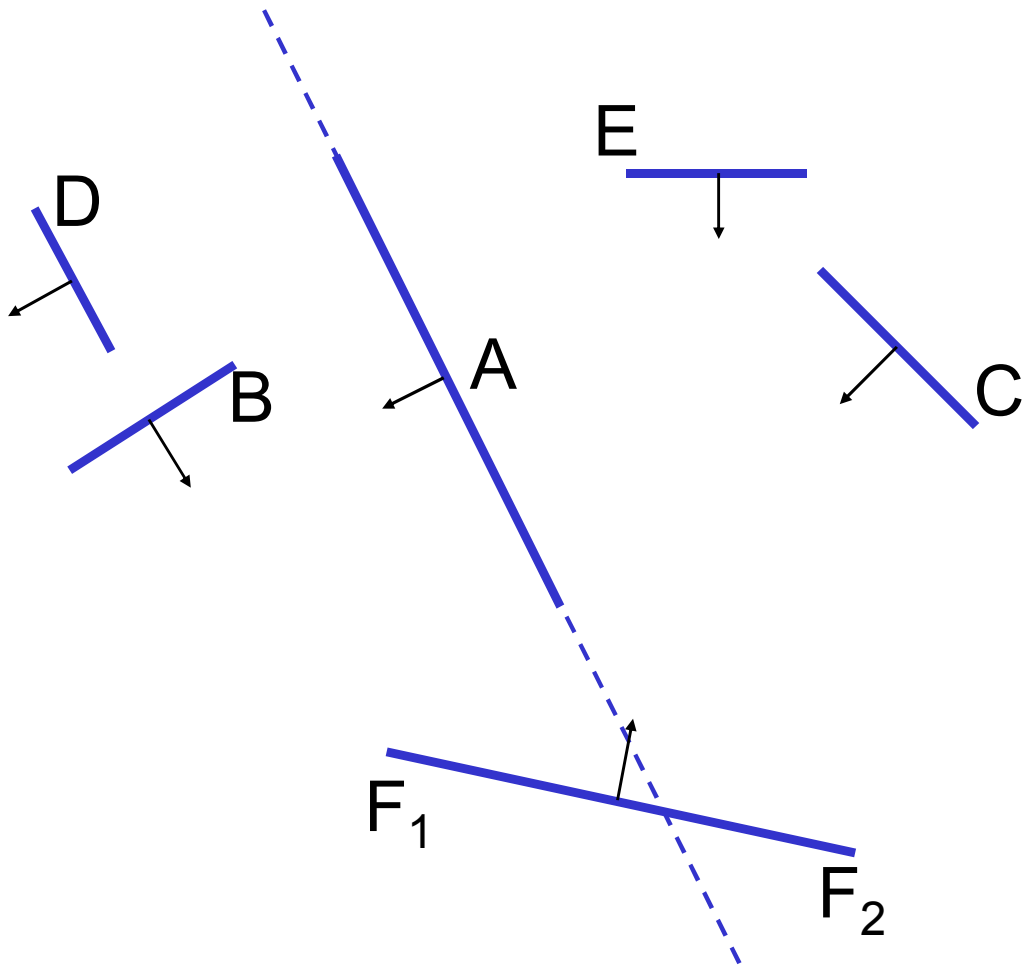
Binary space partition (BSP)

- BSP tree: binary spatial subdivision
- A tree that encodes **viewpoint-independent** and **relative** position/depth information
 - Every node is a splitting plane, which cuts space into two parts (two **half-spaces**)
 - Leads to an ordering with respect to every line in 2D (plane in 3D, etc.)
 - For visibility, the splitting (hyper)planes are defined by the scene geometry

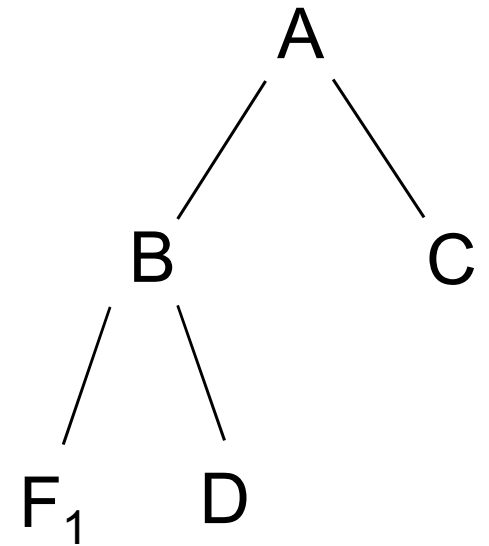
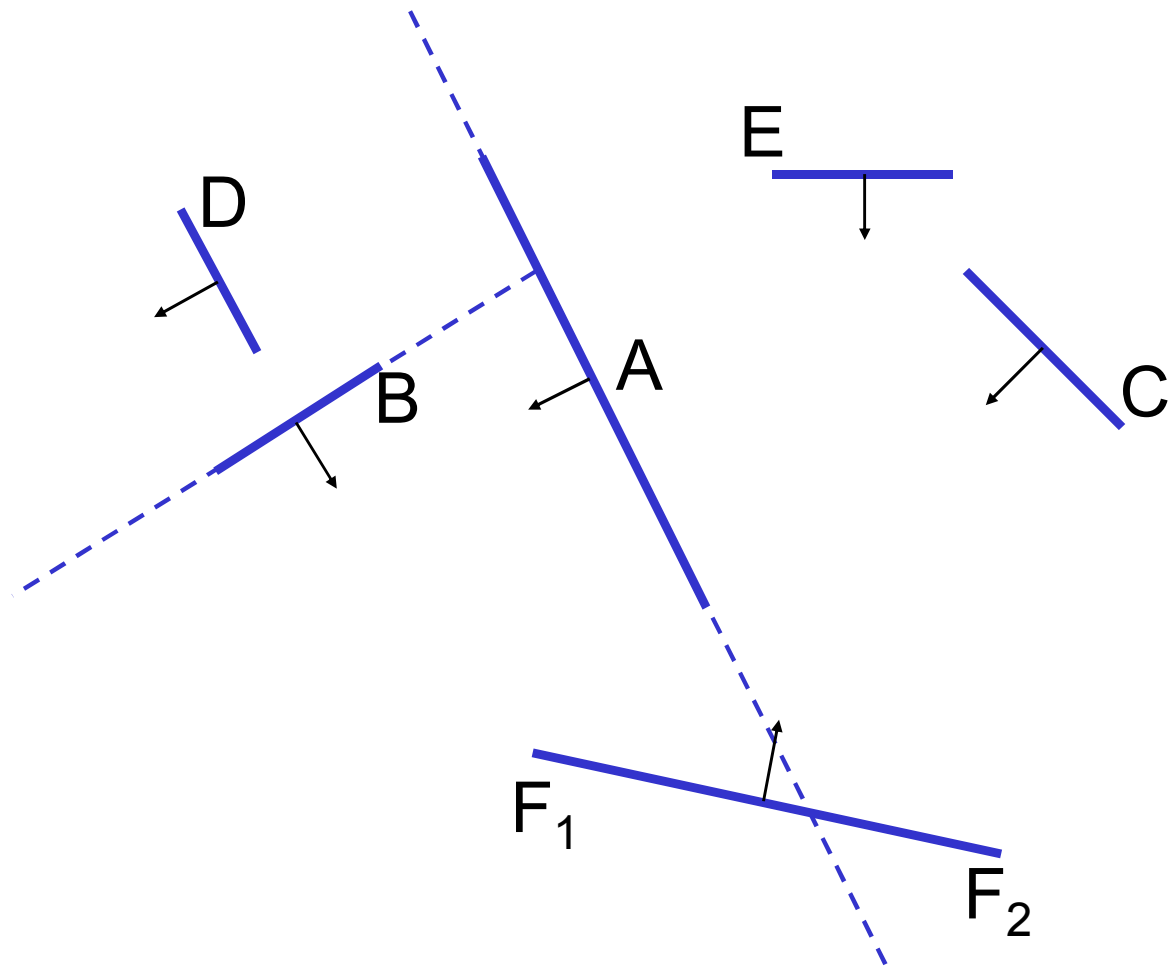
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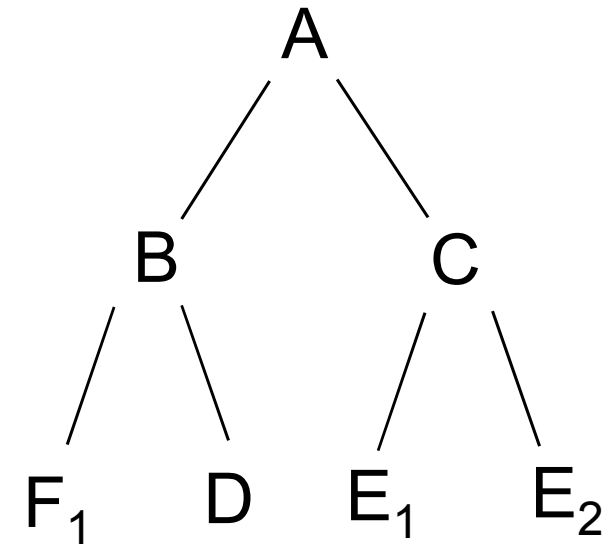
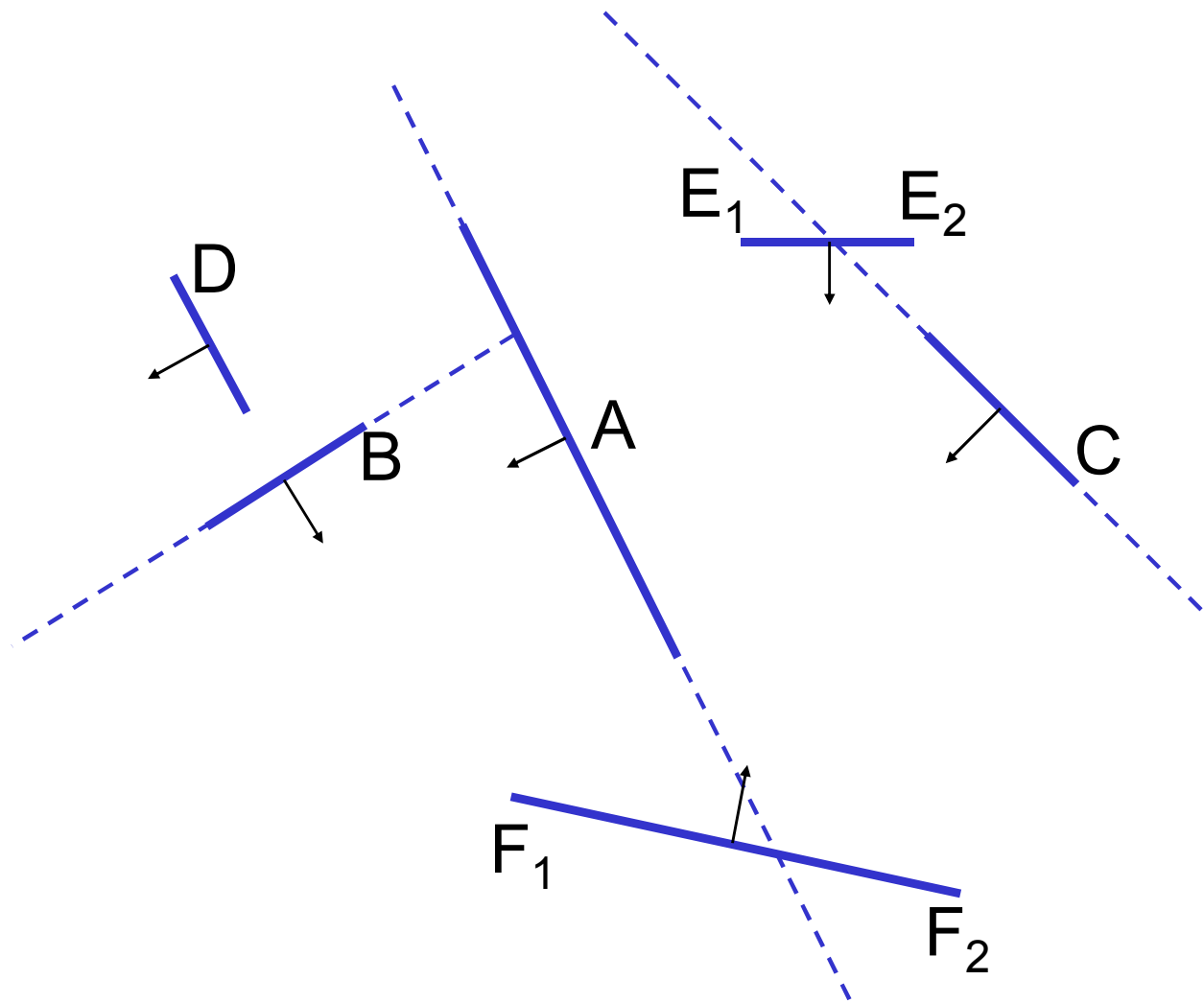
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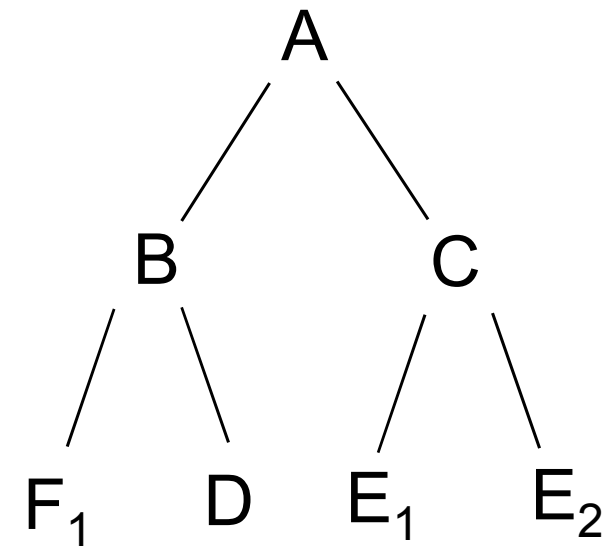
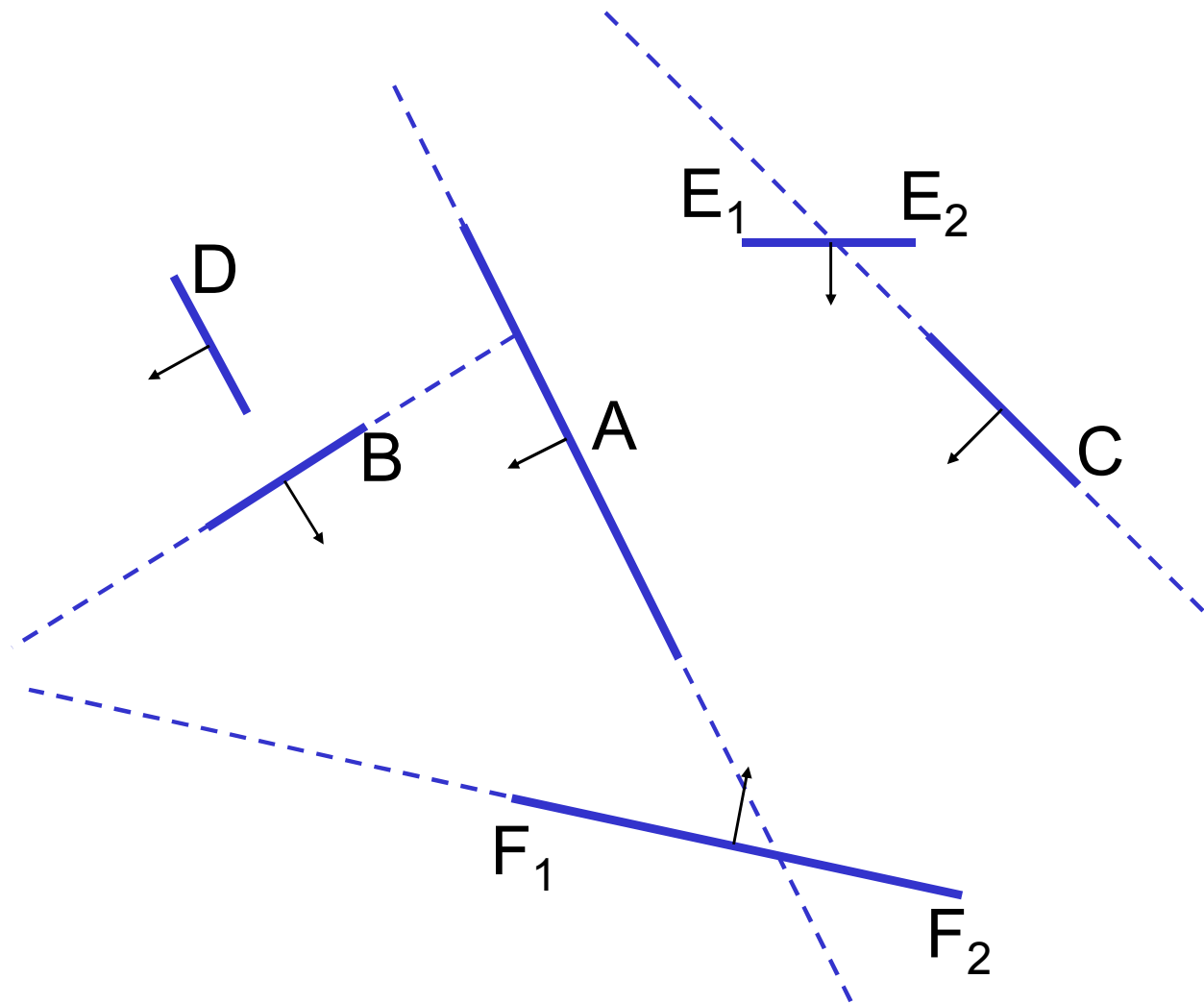
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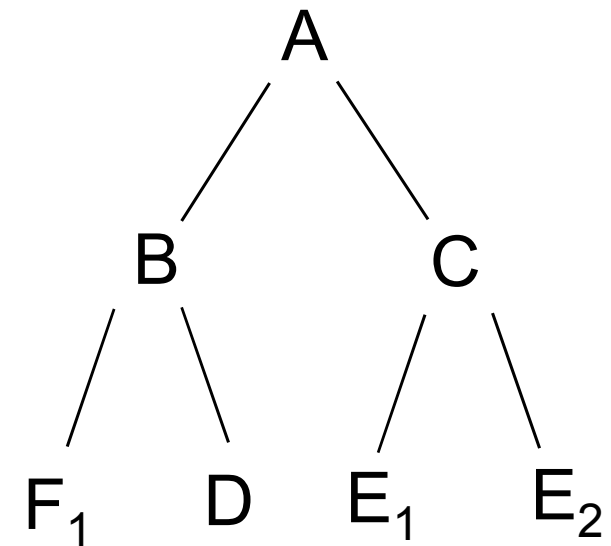
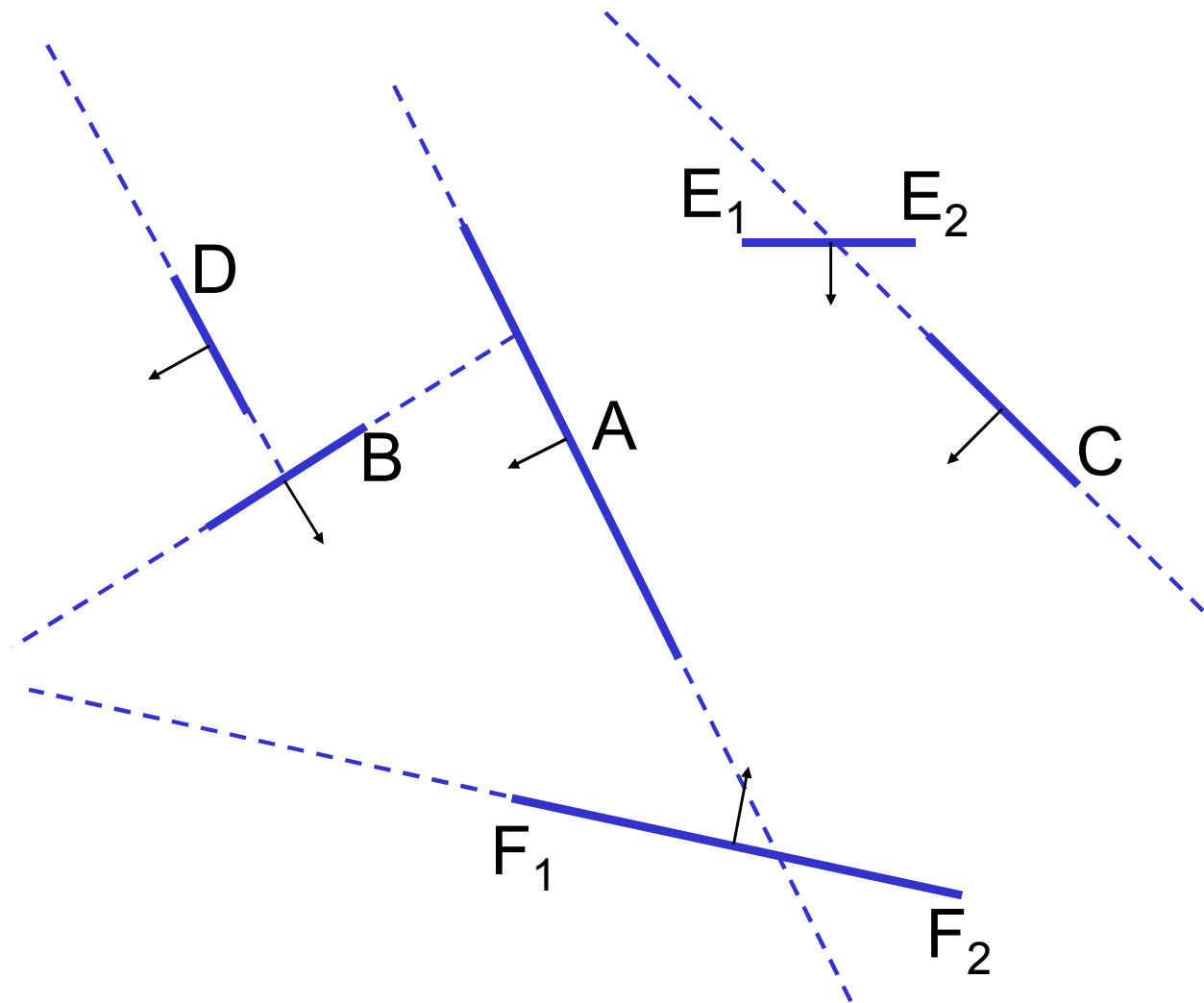
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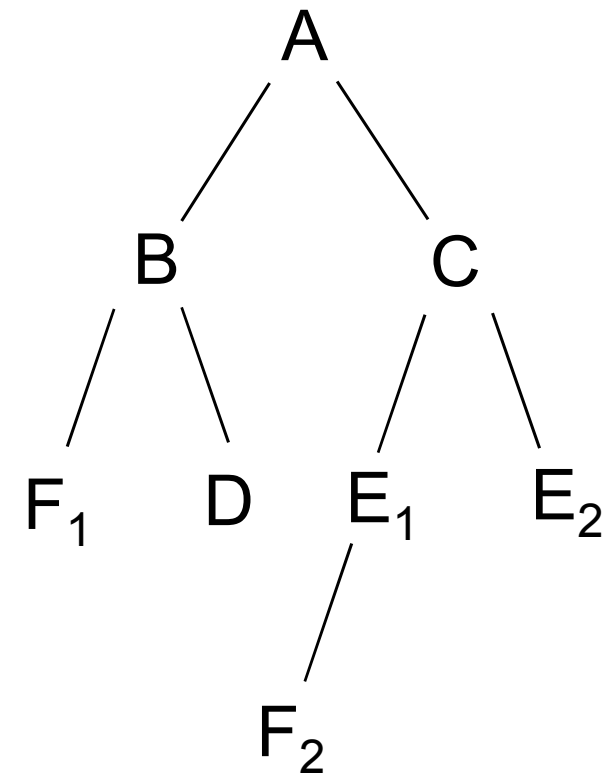
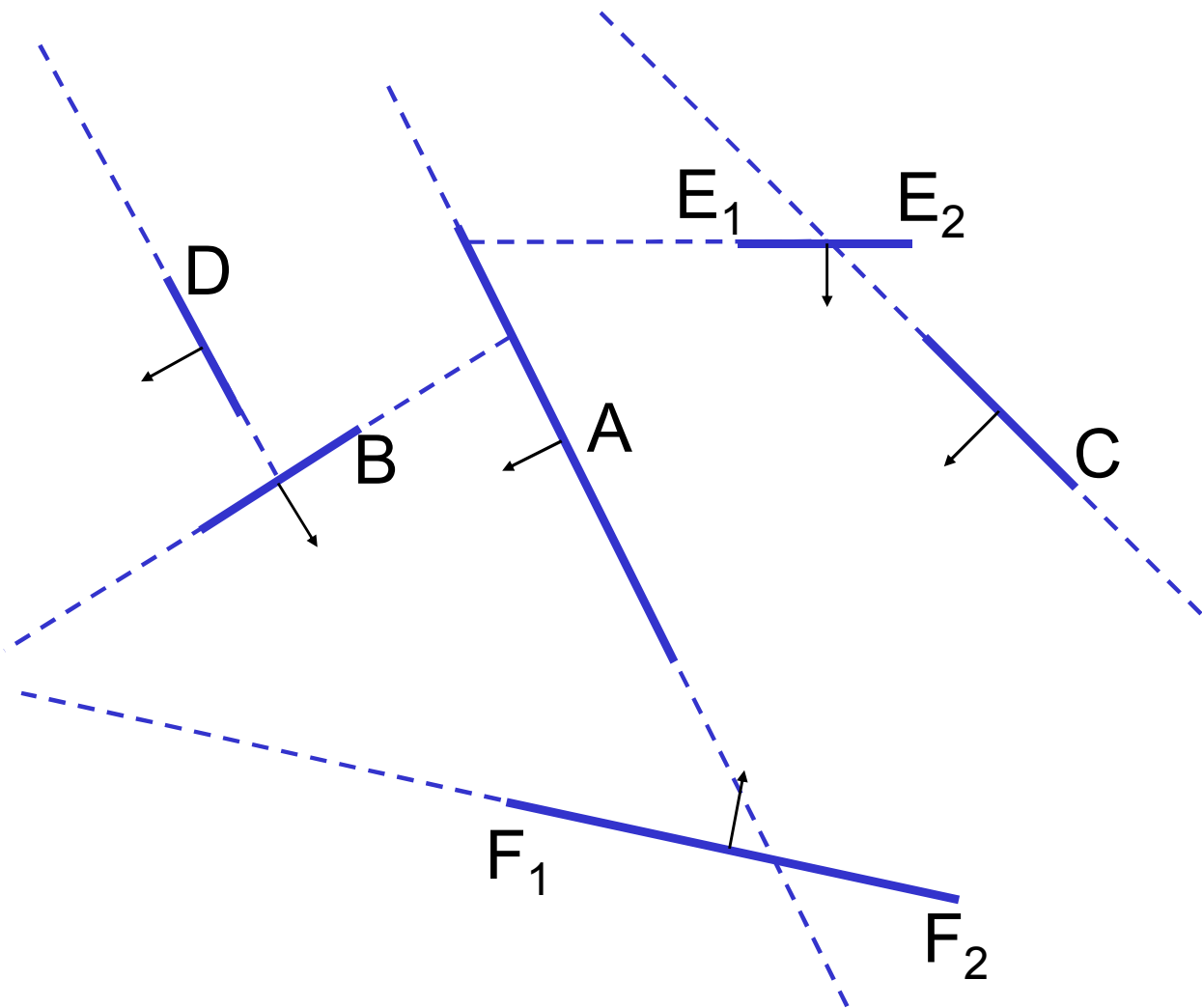
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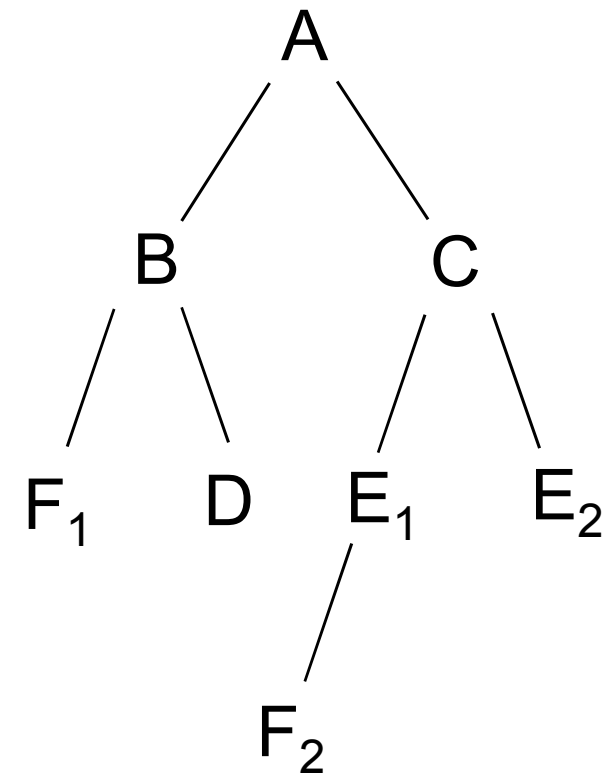
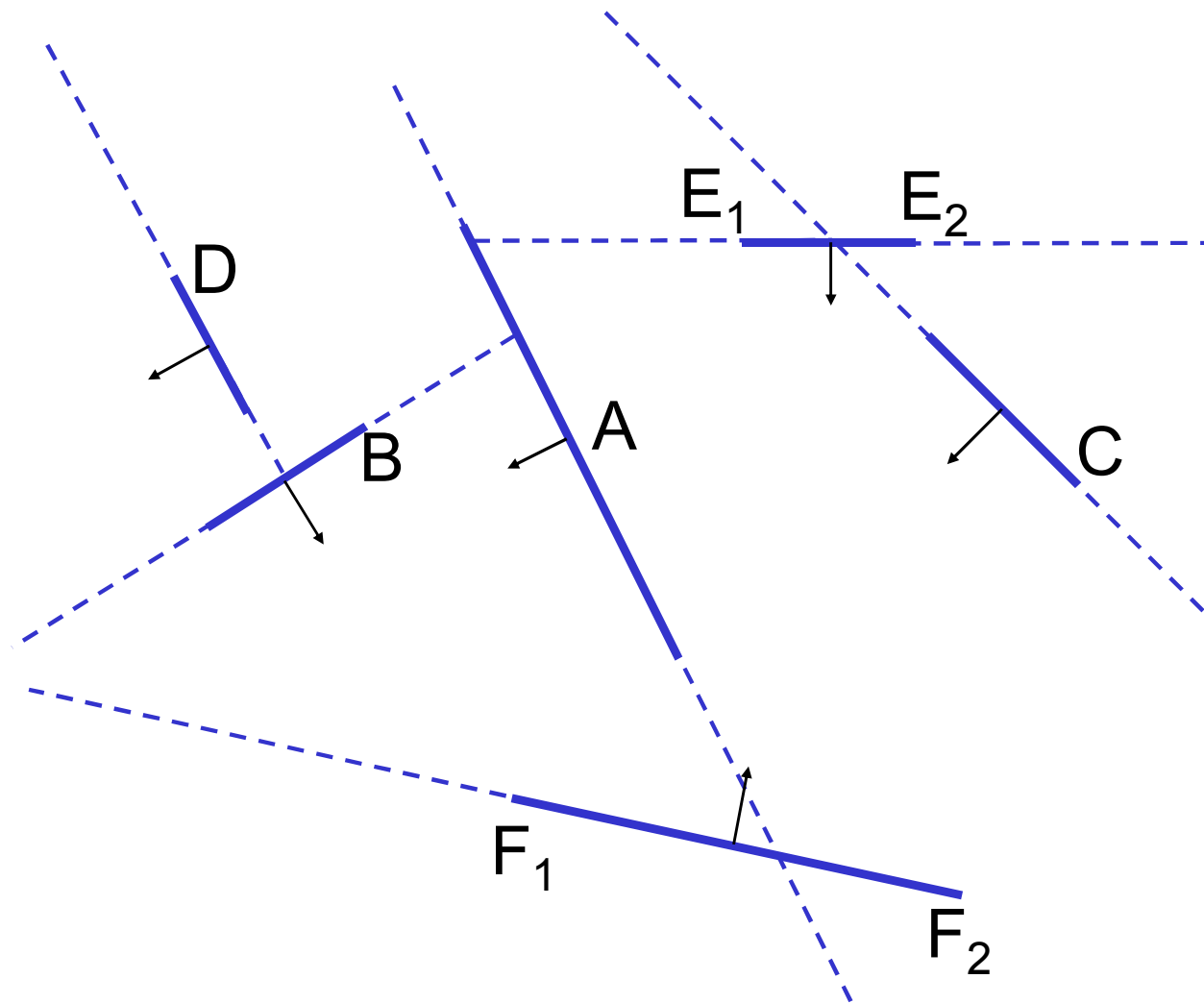
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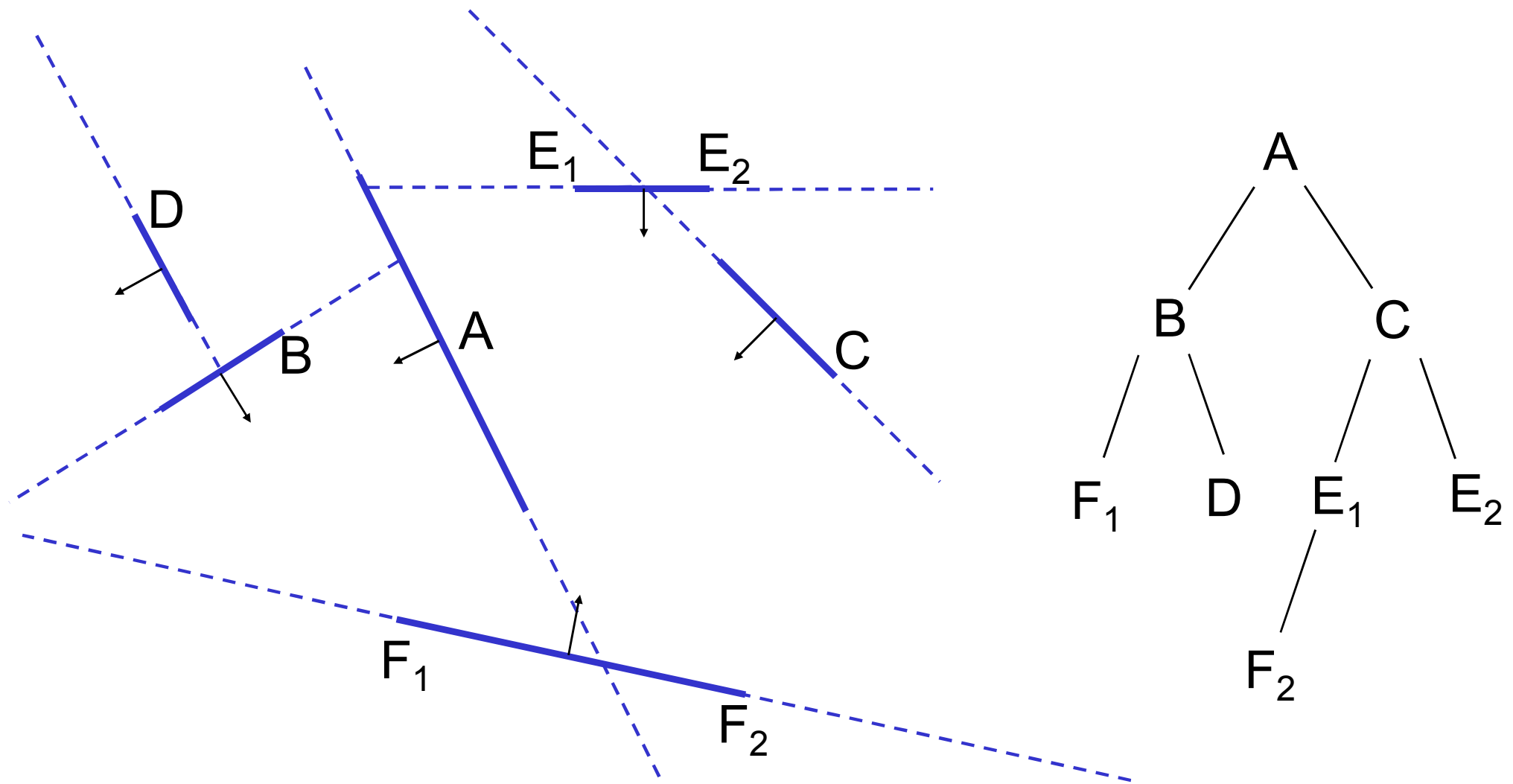
Binary space partition (BSP)



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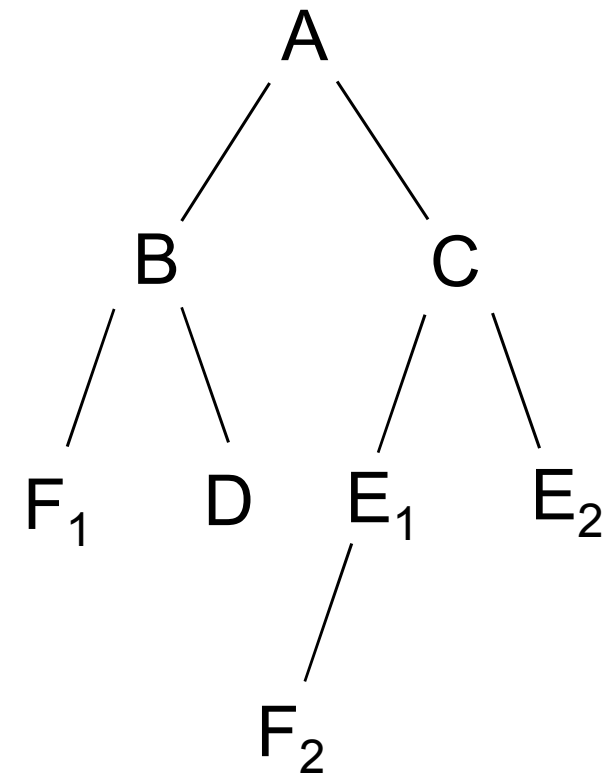
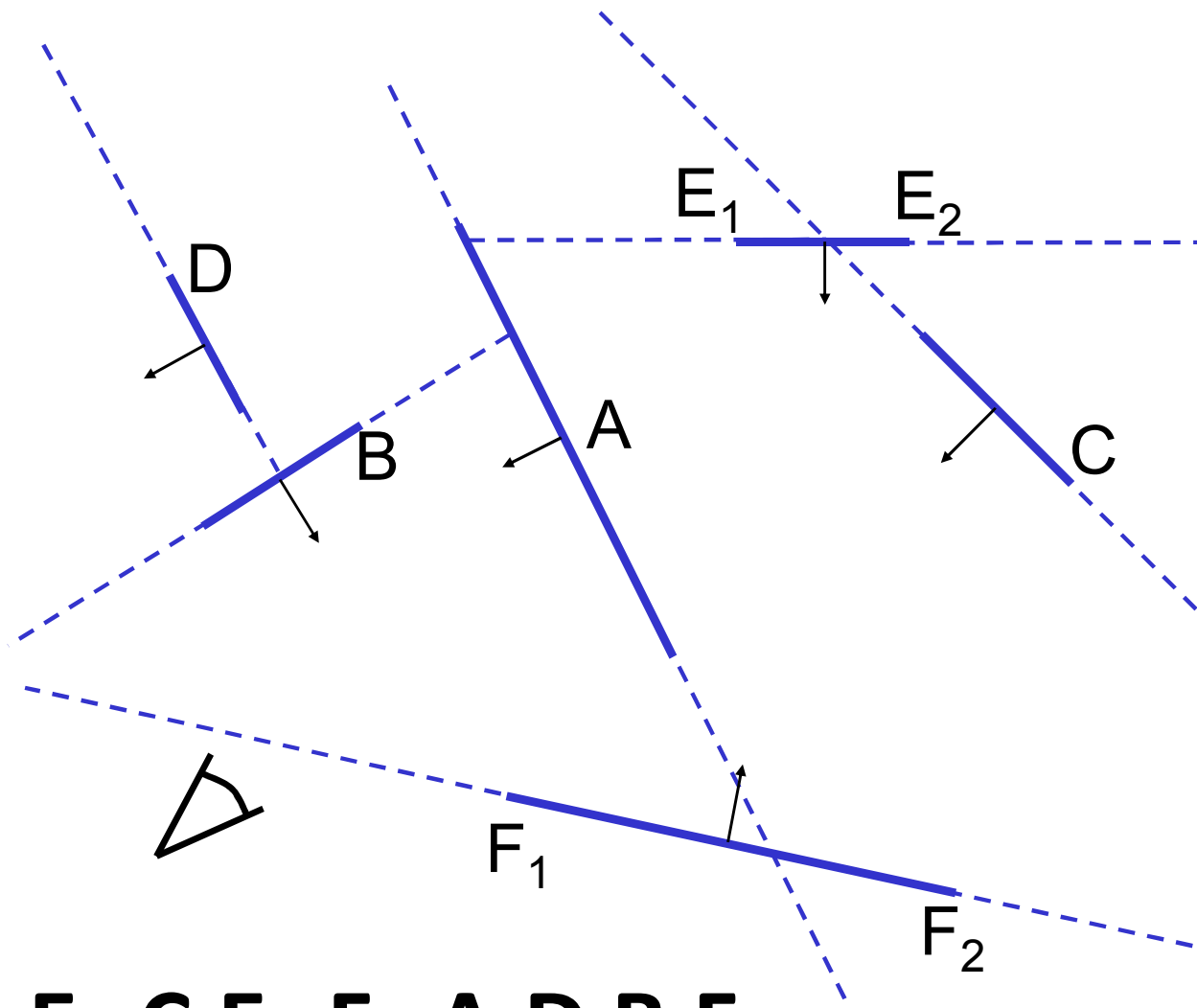


Binary space partition (BSP)

- Ordered list of polygons by traversal
- Identify half-space **H** of eye position

- Traversal ordering
 - Other half-space
 - Polygon (node)
 - Containing half-space **H**

Binary space partition (BSP)



E₂, C, E₁, F₂, A, D, B, F₁

Binary space partition (BSP)

- Some issues
 - Which plane to choose as the splitting plane in each step?
 - How to balance the tree?
 - How to avoid excessive polygon splitting?
- Solution
 - Re-run the algorithm!
 - “Perfect” BSP is in NP (exponential complexity)
 - Randomized version works well, has good expected performance