Simulation in Computer Graphics

1. Positions and velocities of particles over time can be computed from the two governing equations $\boldsymbol{F} = \frac{\mathrm{d}\boldsymbol{v}}{\mathrm{d}t}$ and $\boldsymbol{v} = \frac{\mathrm{d}\boldsymbol{x}}{\mathrm{d}t}$.

   ◯ true ◯ false

2. $\boldsymbol{F} = m\frac{\mathrm{d}^2\boldsymbol{x}}{\mathrm{d}t^2}$ is a second-order ordinary differential equation.

   ◯ true ◯ false

3. Linear second-order ODEs can be rewritten as a system of two coupled linear ODEs of first order.

   ◯ true ◯ false

4. Newton's Second Law can be written as $\boldsymbol{F} = \frac{\mathrm{d}}{\mathrm{d}t}(m\boldsymbol{v})$.

   ◯ true ◯ false

5. Particle simulations are concerned with the computation of unknown future particle quantities $\boldsymbol{x}^{t+h}$ and $\boldsymbol{v}^{t+h}$ from known current information $\boldsymbol{x}^t$, $\boldsymbol{v}^t$ and $\boldsymbol{a}^t$.

   ◯ true ◯ false

6. The explicit Euler scheme updates positions with $\boldsymbol{x}^{t+h} = \boldsymbol{x}^t + h\boldsymbol{v}^t$ and velocities with $\boldsymbol{v}^{t+h} = \boldsymbol{v}^t + \frac{m}{h}\boldsymbol{a}^t$.

   ◯ true ◯ false

7. If a particle i at time t has position $\boldsymbol{x}_i^t = \begin{pmatrix}0\\0\end{pmatrix}$, velocity $\boldsymbol{v}_i^t = \begin{pmatrix}1\\2\end{pmatrix}$, acceleration $\boldsymbol{a}_i^t = \begin{pmatrix}2\\3\end{pmatrix}$, then the Euler-Cromer scheme computes the position $\boldsymbol{x}_i^{t+h} = \begin{pmatrix}10\\16\end{pmatrix}$, velocity $\boldsymbol{v}_i^{t+h} = \begin{pmatrix}5\\8\end{pmatrix}$ for a timestep of $h = 2$.

   ◯ true ◯ false

8. The position update $\boldsymbol{x}^{t+h} = \boldsymbol{x}^t + h\boldsymbol{v}^t$ would be perfectly accurate, if the velocity is constant between t and $t + h$ and equal to $\boldsymbol{v}^t$.

   ◯ true ◯ false

9. A numerical integration scheme is stable, if previously introduced discretization errors do not grow within a simulation step.

   ◯ true ◯ false

10. In particle simulations, the computation time of an explicit numerical integration scheme is dominated by the computation of particle accelerations.

    ◯ true ◯ false

11. Implicit integration schemes often require to solve a linear system.

    ◯ true ◯ false

12. Implicit integration schemes often require to solve a linear system.

◯ true ◯ false

13. Implicit Euler is typically more stable and more accurate than explicit Euler.

◯ true ◯ false

The error order of the implicit Euler scheme is larger than the error order of the explicit Euler scheme.

◯ true ◯ false

14. The Euler-Cromer scheme combines an explicit Euler update for the velocity with an implicit Euler update for the position.

◯ true ◯ false

15. $\boldsymbol{x}^{t+h} = \boldsymbol{x}^t + h\boldsymbol{v}^t + \frac{h^2}{2}\boldsymbol{a}^t + \frac{h^3}{4}\frac{\mathrm{d}^3\boldsymbol{x}^t}{\mathrm{d}t^3} + O(h^4)$ is a Taylor approximation of $\boldsymbol{x}^{t+h}$.

◯ true ◯ false

16. The Verlet integration scheme updates a particle position with $\boldsymbol{x}^{t+h} = 2\boldsymbol{x}^t - \boldsymbol{x}^{t-h} + h^2\boldsymbol{a}^t$.

◯ true ◯ false

17. When I add the two equations $\boldsymbol{x}^{t+h} = \boldsymbol{x}^t + h\boldsymbol{v}^t + \frac{h^2}{2}\boldsymbol{a}^t + \frac{h^3}{6}\frac{\mathrm{d}^3\boldsymbol{x}^t}{\mathrm{d}t^3}$ and $\boldsymbol{x}^{t-h} = \boldsymbol{x}^t - h\boldsymbol{v}^t + \frac{h^2}{2}\boldsymbol{a}^t - \frac{h^3}{6}\frac{\mathrm{d}^3\boldsymbol{x}^t}{\mathrm{d}t^3}$ and solve the resulting equation for $\boldsymbol{x}^{t+h}$, then I get the Verlet update for the position.

◯ true ◯ false

18. The Verlet integration scheme does not necessarily require the particle velocity to update the particle position.

◯ true ◯ false

19. The error order of the Verlet integration scheme is larger than the error order of the explicit Euler scheme.

◯ true ◯ false

20. If the strain of an element i with size V_i is defined as $C_i(\boldsymbol{x}_{i,1}, \boldsymbol{x}_{i,2}) = \frac{1}{L_i}(|\boldsymbol{x}_{i,1} - \boldsymbol{x}_{i,2}| - L_i)$ and if the respective stress is defined as $S_i(\boldsymbol{x}_{i,1}, \boldsymbol{x}_{i,2}) = k_i\ C_i(\boldsymbol{x}_{i,1}, \boldsymbol{x}_{i,2})$, then the elastic energy of the element is: $E_i(\boldsymbol{x}_{i,1}, \boldsymbol{x}_{i,2}) = \frac{1}{2}\ k_i\ \left(\frac{1}{L_i}(|\boldsymbol{x}_{i,1} - \boldsymbol{x}_{i,2}| - L_i)\right)^2\ V_i$.

◯ true ◯ false

21. If the strain of an element i is $C_i(\boldsymbol{x}_{i,1}, \ldots, \boldsymbol{x}_{i,n})$ and the stress is $S_i(\boldsymbol{x}_{i,1}, \ldots, \boldsymbol{x}_{i,n}) = k_i\ C_i(\boldsymbol{x}_{i,1}, \ldots, \boldsymbol{x}_{i,n})$, then the respective elastic forces are computed with $\boldsymbol{F}_{i,j}(\boldsymbol{x}_{i,1}, \ldots, \boldsymbol{x}_{i,n}) = k_i V_i C_i(\boldsymbol{x}_{i,1}, \ldots, \boldsymbol{x}_{i,n})\frac{\partial}{\partial \boldsymbol{x}_{i,j}}C_i(\boldsymbol{x}_{i,1}, \ldots, \boldsymbol{x}_{i,n})$.

◯ true ◯ false

22. Elastic forces do not change the linear and the angular momentum of an element.

◯ true ◯ false

23. In a particle fluid, the viscosity acceleration accelerates particles towards the average velocity of adjacent fluid particles.

◯ true ◯ false

24. In a particle fluid, the pressure acceleration $\frac{1}{\rho}\nabla p$ accelerates particles from regions with higher pressure towards regions with lower pressure.

◯ true ◯ false

25. The density at a fluid particle can be computed with SPH as $\rho_i = \sum_j \rho_j W_{ij}$.

◯ true ◯ false

26. The Lagrange form of the Navier-Stokes equation governs the time rate of change of the velocity of a particle: $\frac{\mathrm{d}\boldsymbol{v}_i}{\mathrm{d}t} = -\frac{1}{\rho_i}\nabla p_i + \nu\nabla^2\boldsymbol{v}_i + \frac{\boldsymbol{F}_i^{\text{other}}}{m_i}$.

◯ true ◯ false

27. The gradient of a quantity A_i at a particle i can be approximated SPH using $\nabla A_i = \sum_j \frac{m_j}{\rho_j} A_j \nabla W_{ij}$.

◯ true ◯ false

28. A popular way to approximate the pressure acceleration with SPH is $-\frac{1}{\rho_i}\nabla p_i = -\sum_j m_j \left(\frac{p_i}{\rho_i^2} + \frac{p_j}{\rho_j^2}\right)\nabla W_{ij}$, as this formulation results in forces that preserve the linear and the angular momentum of the particle fluid.

◯ true ◯ false

29. The equation $p_i = \max\left(k(\frac{\rho_i}{\rho_0} - 1), 0\right)$ is a state equation that allows to compute pressure from a density deviation.

◯ true ◯ false

30. If the density of a particle is smaller than its rest density, then the pressure of that particle is typically set to zero.

◯ true ◯ false

31. An SPH fluid solver performs the following steps in each simulation step: 1. Neighbor search. 2. Density computation. 3. Pressure computation 4. Computation of all accelerations. 5. Position and velocity update of all particles.

◯ true ◯ false

32. In case of a perfect particle sampling, the sum of the SPH kernel values is equal to the size of a particle: $\sum_j W_{ij} = V_i$.

◯ true ◯ false

33. In case of a perfect particle sampling, the sum of the SPH kernel gradient values is zero: $\sum_j \nabla W_{ij} = \mathbf{0}$.

◯ true ◯ false

34. In a rigid-body simulation, one position and one orientation are computed per body over time.

◯ true ◯ false

35. If $\boldsymbol{A}$ is the orientation of a rigid body and $\boldsymbol{\omega}$ is the angular velocity of the rigid body, then the time rate of change of the orientation is: $\frac{\mathrm{d}\boldsymbol{A}}{\mathrm{d}t} = \boldsymbol{A}\boldsymbol{\omega}$.

◯ true ◯ false

36. The angular momentum of a rigid body is the product of its inertia tensor with its angular velocity.

◯ true ◯ false

37. Torque is the time rate of change of the linear momentum.

◯ true ◯ false

38. If two bounding volumes of two different objects overlap, then the enclosed objects interfere.

◯ true ◯ false

39. If two bounding volumes of two different objects do not overlap, then the enclosed objects do not interfere.

◯ true ◯ false

40. Axis-aligned bounding boxes can be rotated along with an object.

◯ true ◯ false

41. Axis-aligned boxes are a special case of k-DOPs.

◯ true ◯ false

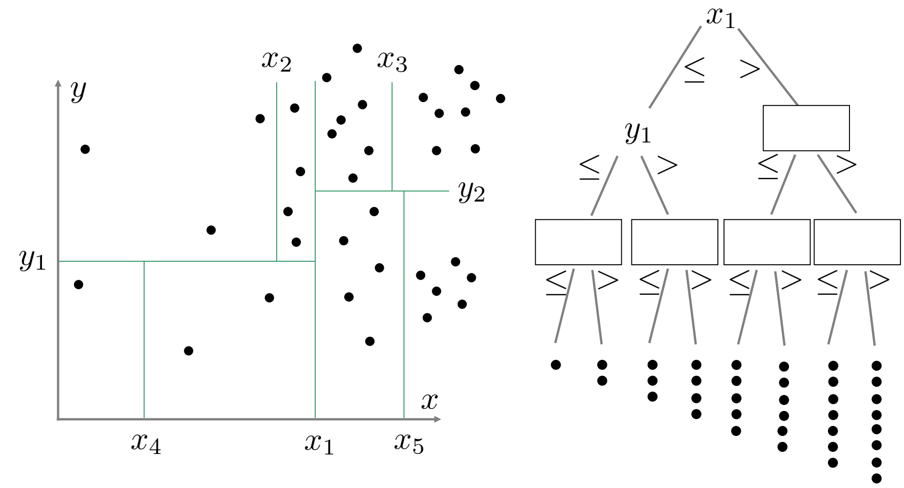
42. OBBs can be rotated along with an object.

◯ true ◯ false

43. The performance of a uniform grid depends on the ratio between the object primitives or elements and the cell size. For an optimal efficiency, the primitives or elements should approximately correspond to the cell size.

◯ true ◯ false

44. Enter the missing entries into the k-d tree.



45. Enter the missing entries into the BSP tree.