# CPSC 426: Computer Animation
# Practice Questions

April 14, 2014

Answer the questions in the spaces provided on the question sheets. If you run out of room for an answer, continue on the back of the page.

Name: _____

Student Number: _____

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|---|---|
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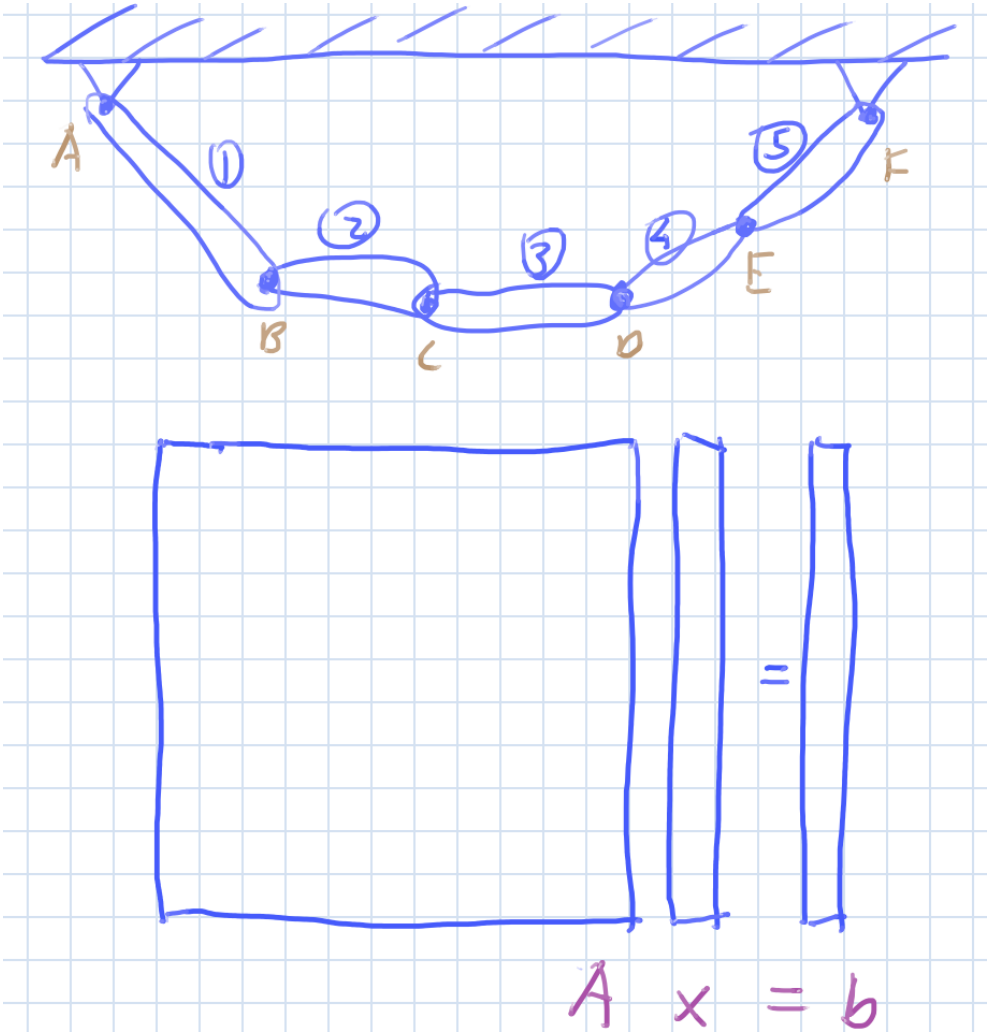
There are 8 questions, for a total of 39 points.

1. (4 points) Equations of Motion

   Given the equations for linear momentum, $\overrightarrow{P} = m\overrightarrow{V}$, and angular momentum, $\overrightarrow{L} = I\overrightarrow{\omega}$, derive the Newton-Euler equations of motion and circle the unknowns that are solved for during forward dynamics simulation.

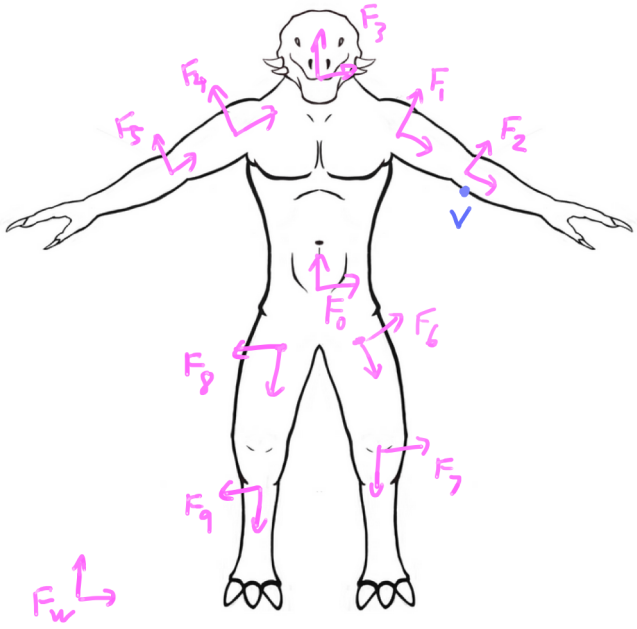
2. (4 points) Articulated Figure Dynamics

   Provide the block structure for the equations of motion, $Ax = b$, for the following articulated figure by: (a) providing a list of the unknowns in the $x$ column, and (b) shading the blocks within the $A$ matrix that would have non-zero entries.



3. Skinning

(a) (1 point) Sketch the scene hierarchy for the character shown below. On this diagram, also label the relative transformation matrices $M_n$, where, $M_n$ takes a point from coordinate frame $n$ to its parent's coordinate frame.



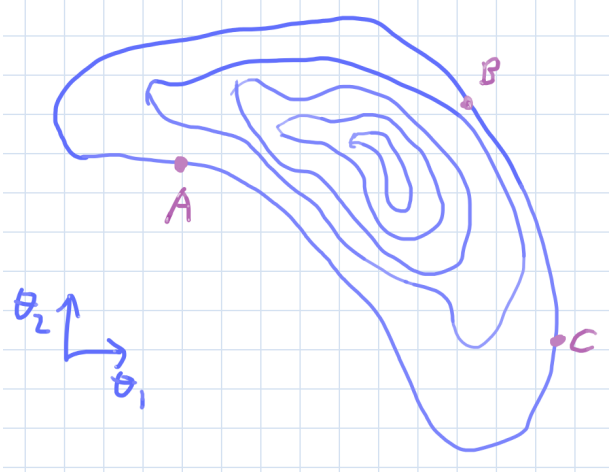

(b) (1 point) Give expressions for:
$M_{2\to W} =$
$M_{3\to 2} =$

(c) (1 point) A vertex $V$ has the following skinning weights: $w_1 = 0.2, w_2 = 0.8$. Let $M_{1\to W}$ and $M_{2\to W}$ define the transformation matrices for the skeleton in the bind-pose, i.e, the above T-pose. Let $M'_{1\to W}$ and $M'_{2\to W}$ define the transformation matrices for a current desired pose. Give an expression for the new vertex coordinates, $V'_W$ for a vertex that has coordinates given by $V_W$ in the original bind pose.

(d) (1 point) Linear blend skinning will cause "pinching" artifacts at joints when they bend. How can this be fixed within a linear blend skinning framework?

4. Inverse Kinematics

Consider the minimization problem depicted using the "contour map" shown below. Assume that the lowest contours are located in the middle.




(a) (1 point) Sketch the path that coordinate descent with a fixed step size would follow from point $A$, beginning with the $\theta_1$ direction.

(b) (1 point) Sketch the path that gradient descent with a fixed step size would follow from point $B$.

(c) (1 point) Sketch the path that cyclic coordinate descent would follow from point $C$, beginning with the $\theta_1$ direction.

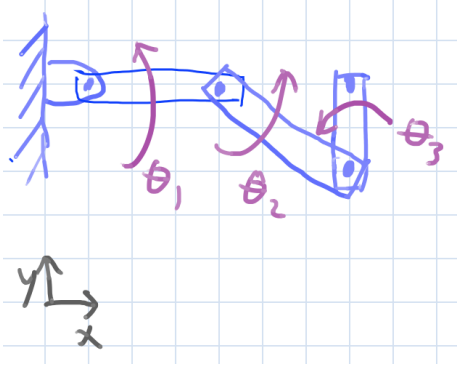
(d) (1 point) Which of the above methods would make use of the Jacobian transpose?

(e) (1 point) T or F: The pseudoinverse method takes steps that minimize the movement in joint space.

(f) (1 point) T or F: Inverse kinematics problems are generally overconstrainted.

(g) (1 point) T or F: Iterative IK methods converge to the same solution regardless of the intial starting state.

(h) (2 points) Give the Jacobian matrix for the arm configuration shown below. Assume that the $x, y$ dimensions are measured in units where 1 grid cell equals 1 unit.



5. Particle systems

   (a) (2 points) Give the basic pseudocode for a simple particle system simulation, where all particle move independently and experience a gravitational force as well as a drag force that is porportional to the current velocity. Assume that the particle positions and velocities have already been initialized.

   (b) (1 point) Assume that the state of a dynamical system is given by a vector $X(t)$ and that $dX/dt = f(t, X(t))$. Write an expression for an explicit integration update of the state $X(t)$ after a time step of $\Delta t$.

   (c) (1 point) Using the same assumptions as above, write an expression or equation to be solved for an implicit integration update of the state $X(t)$ after a time step of $\Delta t$.

   (d) (1 point) What is a 'splat' in computer graphics?

6. Motion Capture

(a) (3 points) Define the following:
Motion retargeting:

Footskate:

Dynamic time warping, as applied to motion capture data:

(b) (3 points) List the primary advantages and disadvantages of:

Passive optical motion capture:

Motion capture using intertial measurement units, i.e., accelerometers + solid-state gyros:

Mechanical motion capture, i.e., using potentiometers

7. The Principles of Animation
   (a) (1 point) What is meant by "secondary action"?

   (b) (1 point) What is meant by "staging"?

   (c) (1 point) Aside from the above, list four other principles of animation.

8. Guest lectures
   (a) (1 point) What is "curl noise"?

   (b) (1 point) Explain the difference between an animation studio and a visual effects studio.

   (c) (1 point) What are the key steps in preparing a VFX shot?

   (d) (1 point) What is an "animatic"?