

Animation and Movie Making

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Intended Learning Outcomes

- Distinguish two **types** of animation
- Describe the four **steps** of animation
- Describe **key frame** and **intermediate frame** generation techniques
- Able to model and program common animation effects such as **acceleration**, **deceleration**, and **periodic** motion

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Two Types of Animation

- Real time animation
 - Update parts of image in real time as soon as available
- Frame by frame animation
 - Use two frame buffers
 - Display first buffer content
 - Update on the second buffer
 - Switch the two buffers when the new image has finished drawing on the second buffer
 - Use in system that does not require real time e.g. movie production

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Comparisons

- ❑ Real time animation

- Adv. Critical Information displayed as soon as available
- Disadv. Refresh rate of each pixel must be at least 16 frames/sec to avoid flickering
- Used in real time systems e.g. flight simulator, multi-player games

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- ❑ Frame by frame animation

- Adv. No flickering even if the refresh rate is low
- Disadv. Display of information may be delayed up to one frame
- Used in non-real time systems e.g. movie

Designing an Animation

■ Story Board

- outline of the action. Defines the motion sequence as a set of basic events that are to take place

■ Object Definitions

- choose the object representation and movement of each object in the story

■ Generation of Key Frames

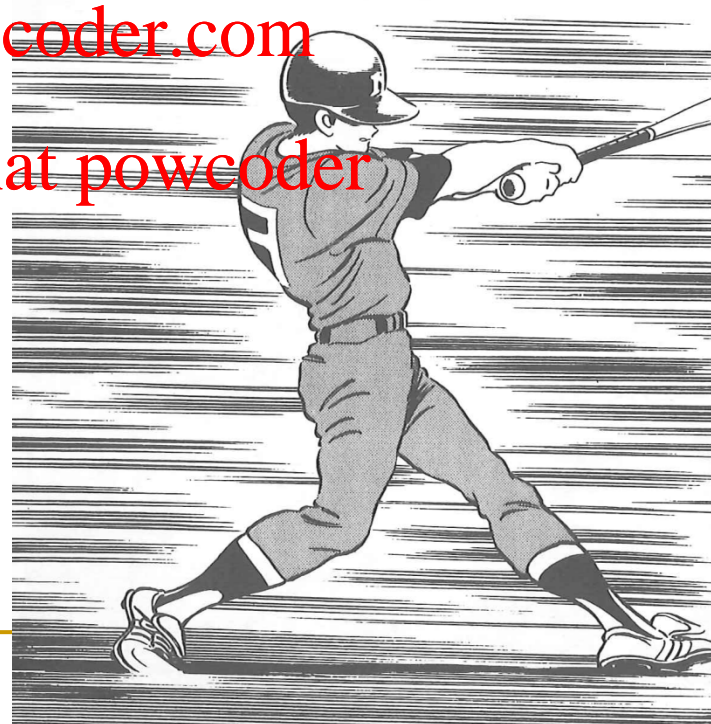
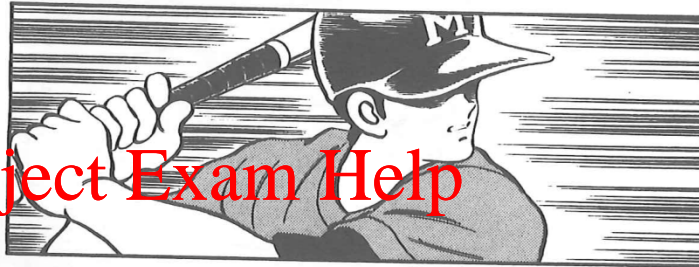
- generate a detailed image of the scene at a certain time in the animation sequence
- More key frames are specified when the motion is intricate

■ Generation of In-between Frames

- Intermediate frames between the key frames.
- The number of in-betweens needed is determined by the media to be used to display the animation.

Key frames

From comic "H2"



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Generation of in-between frames from key frames

- Key frames can be generated by the CG pipeline
- Morphing can be used to generate in-between frames
- Morphing – short form for metamorphosis
- It is a transformation of object shape from one form to another

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Morphing

- Step 1 : Equalize the number of vertices of the two shapes
- Step 2 : Find correspondence between each pair of vertices
- Step 3 : Find intermediate positions of the vertices by interpolation

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Algorithm

Input : Key frames k and $k+1$

Algorithm

1. Let V_k be the number of vertices in key frame k . Compute

$$V_{\max} = \max(V_k, V_{k+1}) \quad V_{\min} = \min(V_k, V_{k+1})$$

and

$$N_{ls} = (V_{\max} - 1) \bmod (V_{\min} - 1)$$

$$N_p = \text{int}\left(\frac{V_{\max} - 1}{V_{\min} - 1}\right) \quad // \text{int}(x) \text{ takes the largest integer smaller than } x$$

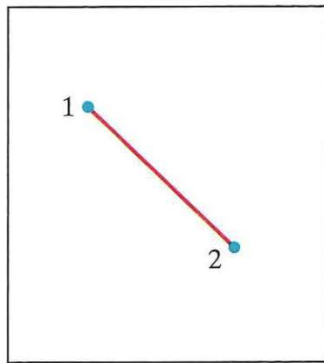
2. Add N_p points to N_{ls} line sections of keyframe_{\min} (the key frame with less number of vertices)

Add $N_p - 1$ points to the remaining edges of keyframe_{\min}

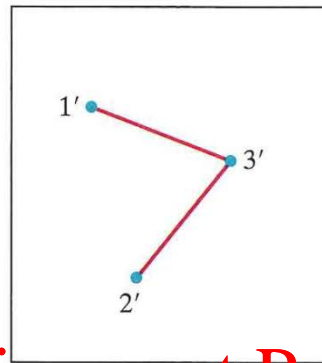
// now both key frames have equal number of vertices

3. Linearly interpolate for each pair of corresponding vertices in the two key frames to generate the in-between frames

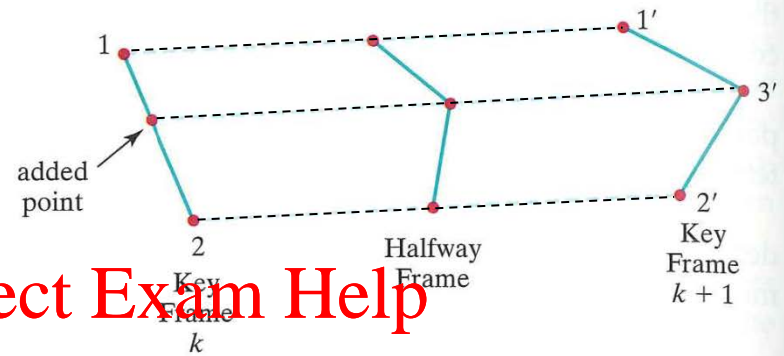
Output: a set of in-between frames



Key
Frame k



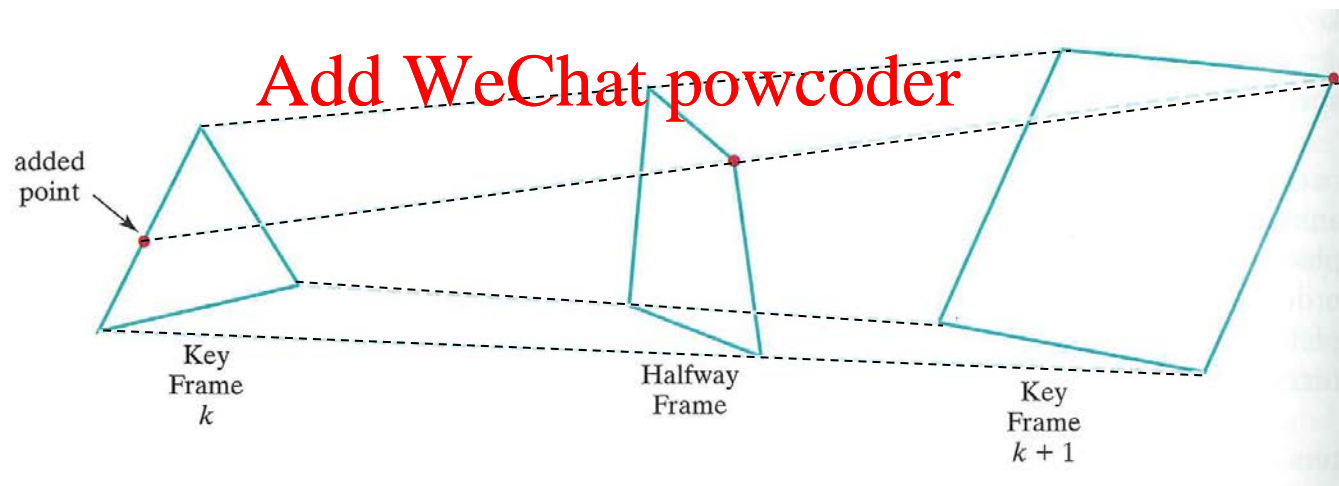
Key
Frame $k + 1$

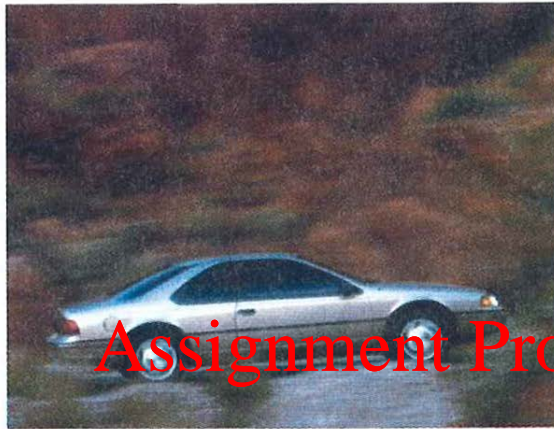


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(a)



(b)



(c)



(d)

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Simulating Acceleration and Deceleration

- Idea : Adjust the time spacing of successive frames
- n in-between frames for two key frames at $t = t_1$ and t_2
- Constant velocity

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$$tB_j = t_1 + \frac{j\Delta t}{n+1} \quad j=1, 2, \dots, n \quad \Delta t = t_2 - t_1$$

Empirical functions

- Acceleration: Use empirical function $1 - \cos \theta$ $0 < \theta < \pi/2$

$$tB_j = t_1 + \Delta t \left[1 - \cos \frac{j\pi}{2(n+1)} \right]$$

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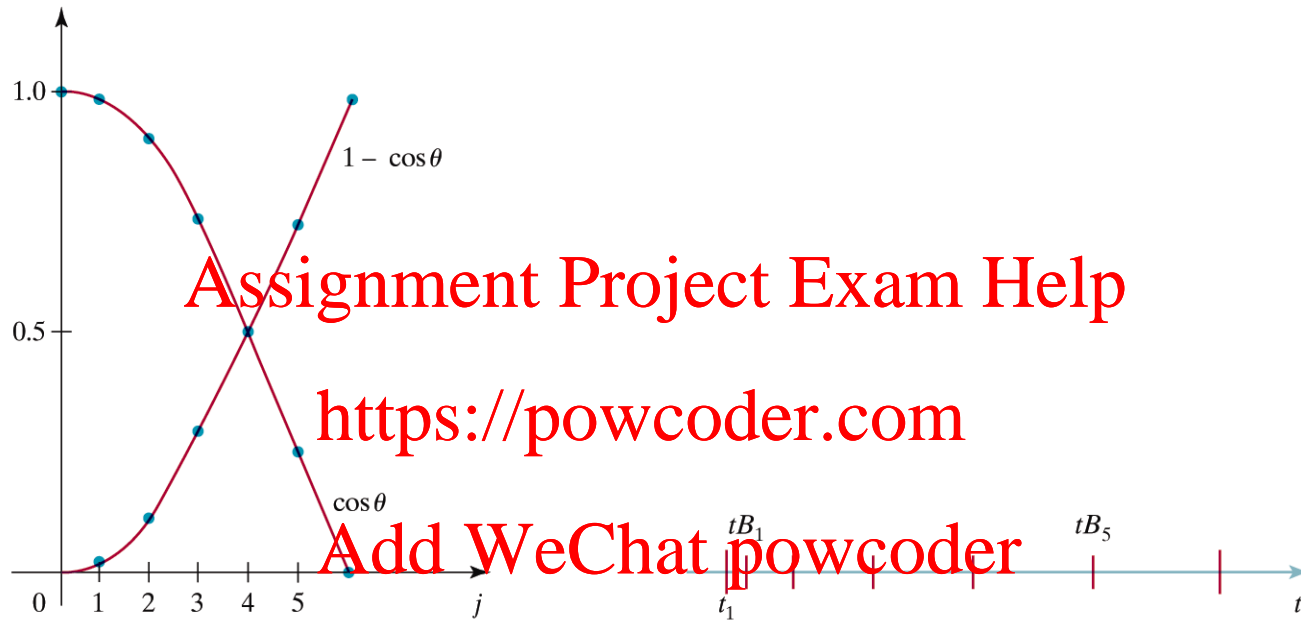
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- Deceleration: Use $\sin \theta$

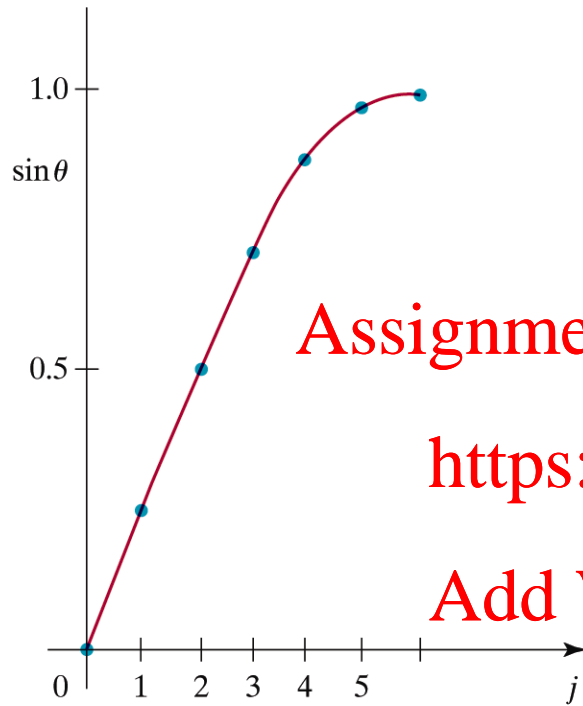
$$tB_j = t_1 + \Delta t \left[\sin \frac{j\pi}{2(n+1)} \right]$$

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- Accelerate then decelerate: Use $\frac{1}{2}(1 - \cos \theta)$ $0 < \theta < \pi$



Acceleration



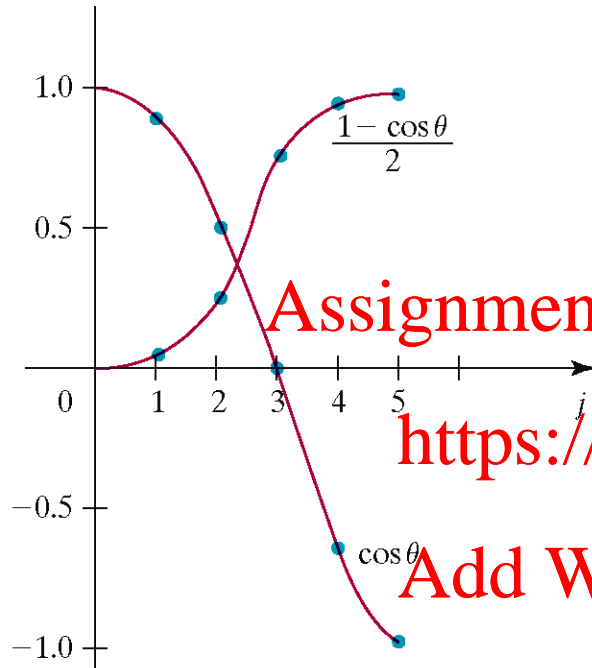
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Deceleration



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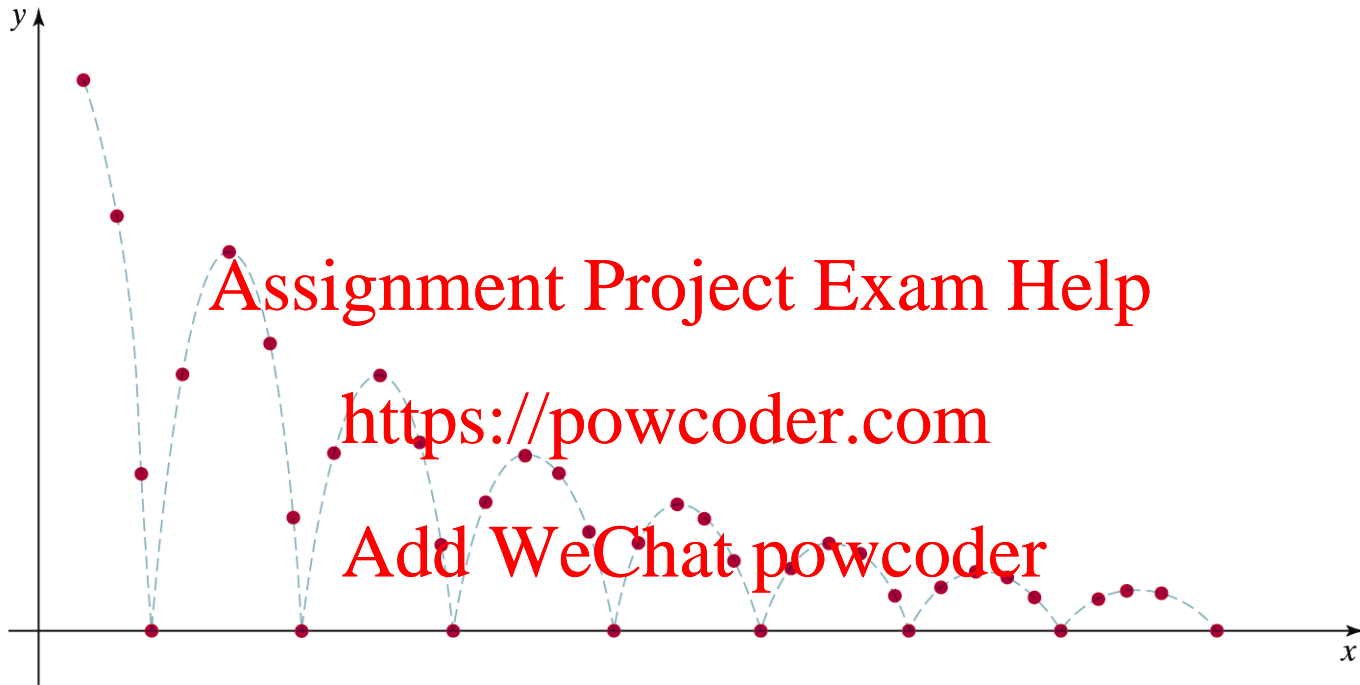


Acceleration then Deceleration

Specifying Motion (1)

- For general motions, empirical functions are not accurate enough
- Three ways to calculate motion
 - Direct Motion specification
 - Solve the motion equations, then just plot the trajectory
 - Example: simple harmonic motion
 - Kinematics and dynamics
 - Kinematics : calculate position, velocity and acceleration

$$v = u + at \quad s = s_0 + ut + \frac{1}{2}at^2$$



Simple harmonic motion

Specifying Motion (2)

- Inverse Kinematics

Specify the initial and final conditions, then the system solves for the motion

- Dynamics

Specify the forces : Physically based modelling

$$F - kv - h(A - x_0) = ma$$

- Inverse Dynamics

- Goal Directed System

- Specify desired behaviour : “Walk”, “Run”

- Converted into mathematical motion by the system

Periodic Motion

- Motion must be synchronized with the frame rate, otherwise may result in incorrect motion
- A typical example is shown in the figures below.
- Solutions
 - Generate a frame after each fixed angle increment, but this may cause other problems if the periodic motion is too fast
 - Use timer and ask user to have a certain minimum graphics capability in their computer (common practice in games)
 - Periodically reset parameters to prevent numerical error build up

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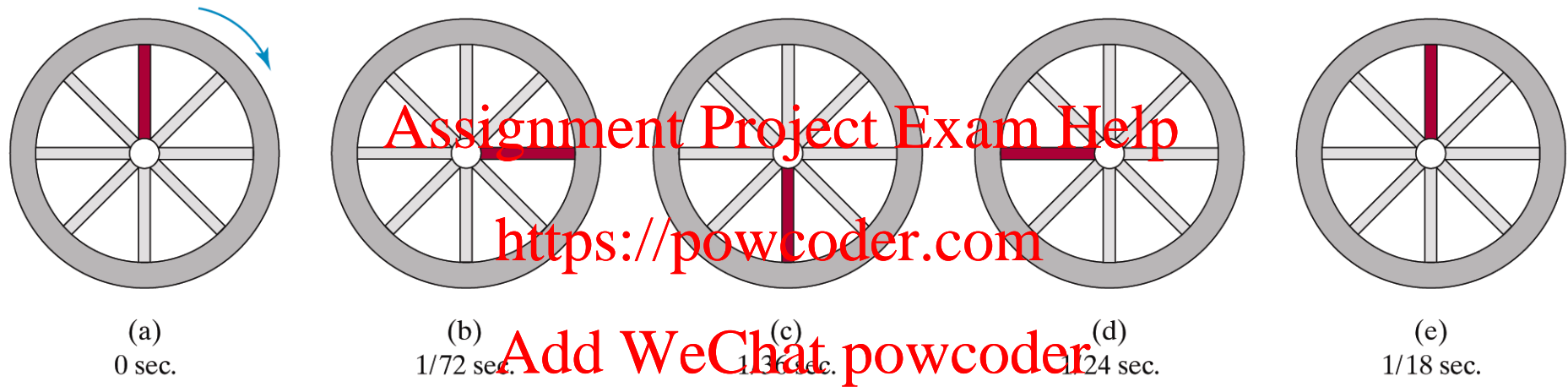
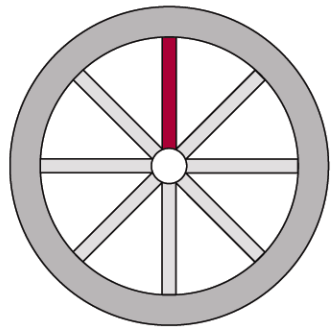
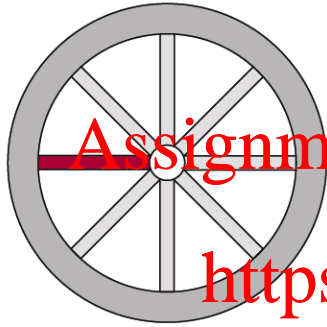


Figure 13-21

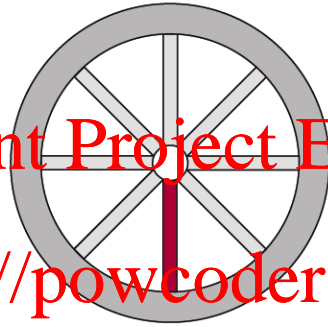
Five positions for a red spoke during one cycle of a wheel motion that is turning at the rate of 18 revolutions per second.



Frame 0
0 sec.



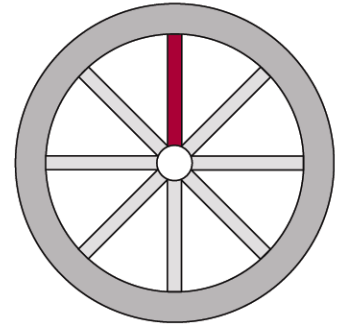
Frame 1
 $1/24$ sec.



Frame 2
 $2/24$ sec.



Frame 3
 $3/24$ sec.



Frame 4
 $4/24$ sec.

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The first five film frames of the rotating wheel in Fig. 13-21 produced at the rate of 24 frames per second.

OpenGL Commands

- Double Buffering

- `glutInitDisplayMode (GLUT_DOUBLE)`
- `glutSwapBuffers ();`

- To produce an animation

- `glutIdleFunc (animationFcn)`
- `animationFcn` is a procedure written by the user to update the animation parameters
- `glutPostRedisplay ();`

- See example program in pg. 410

- Using the timer

- `glutGet(GLUT_ELAPSED_TIME)`

References

- Text: Ch. 12

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