Intro to Digital Signal Processing MMP505

Fall 2026

Instructor: Prof. Dr. Christoph Thompson

Office: MI210

Office Hours: Thursday 14:00–16:00, or by appointment

Email: cnthompson4@bsu.edu

COURSE INFORMATION

Course Description: An introductory course in Digital Signal Processing. Topics include basic digital filters and artificial reverberation, with exploration of both script- and graphic-based programming languages, game environments such as Unreal, and middleware such as FMOD.

Prerequisites: MMP236 / Game Design major / instructor permission

Course Goals / Learning Outcomes: By the end of MMP305, students will be able to apply basic DSP techniques and programming in practice, will have working knowledge of Reaktor® and other audio/DSP scripting languages, and will understand audio codecs and immersive interactive environments such as the Unreal® engine.

Course Modality / Structure: The course is divided into six modules, each focused on a major topic in digital signal processing. At the end of each module, students submit a practical DSP project and take a quiz on the material. This is a lab-focused course.

Course Time Commitment: Students should expect to spend approximately 2 hours of study time outside of class for every 1 hour in class — an average of 6 hours per week outside of class for this 3-unit course.

COURSE MATERIALS

Recommended texts:

- A. V. Oppenheim, Ed., Applications of Digital Signal Processing
- Acoustics and Psychoacoustics, Howard and Angus
- The Mainstream of Algebra and Trigonometry, A. W. Goodman
- Game Audio Implementation, Richard Stevens

COURSE STATEMENTS AND POLICIES

Citation Format

This course uses the IEEE citation format as well as the AES formatting guidelines:

- IEEE Citation Guidelines
- AES Author Guidelines

Participation Policy

- This course is designed with weekly activities, discussion, and other forms of regular collaboration and communication.
- It is recommended that you log into your course 3–4 times a week and check your official Ball State email account daily for announcements and class preparation.

- Each lab session opens with a few minutes reserved for questions on the previous session's material before new content begins — use this time freely.
- Complete all assignments, quizzes, tests, and other activities by the stated due dates.

Attendance Policy

- **Students are expected to attend all class sessions. Three absences will result in a 10% reduction of final grade percentage, four absences a 20% reduction. Five absences will result in an F for the course.**
- **Two tardy entrances will be considered one absence.** This applies to online attendance as well.
- Absence during an in-class exam will be tolerated only under extreme circumstances and requires medical documentation; in that case the exam must be completed before the next class meeting.
- All excuses for absences, whether medical or otherwise, are at the discretion of the instructor.

Review the University Attendance Policy: https://www.bsu.edu/about/administrativeoffices/vice-provost/student-services/attendance-policies

Feedback Policy

- Email from your official Ball State address will be answered within 24 hours on weekdays and 48 hours on weekends.
- Every discussion post will be read, though not every post will receive a personal reply.
- Quizzes, assignments, and discussions will be graded no later than 5 business days after submission.
- Contact the instructor directly with questions or concerns about your performance in class.

Late Assignment Policy

- All assignments are due by midnight EST/EDT on the indicated due date.
- Work submitted after the due date is subject to a decreased letter grade for each day late.
- Turn in work early and often, and keep a back-up plan for connectivity or technical issues.
- One (1) late assignment is permitted, allowing a single assignment to be submitted up to 24 hours late.
- Canvas will not accept assignments for grading after 11:59 pm on the final day of class.

Grading Policy

Appropriate evaluation of academic performance is an integral part of the learning experience. In the absence of mistake, fraud, bad faith, or incompetence, the instructor is the key decision-maker on the assignment of grades. Rubrics for every lab project are posted in Canvas alongside the assignment at the time it is released, and the grading criteria for each project are reviewed in class before work begins. For information on grade appeals, consult the Ball State Grade Appeals page.

Grade Distribution

Component	Weight	Grade	Range
Lab Projects	25%	A / A-	90 - 100
Reading / Participation	25%	B+ / B / B-	80 - 89
Midterm (Hackathon + Presentation)	10%	C+ / C / C-	70 - 79
Midterm Project	15%	D+ / D / D-	60 - 69
Final Project	25%	F	Below 60

UNIVERSITY POLICIES

We are committed to ensuring that all members of the community are welcome, through valuing the various experiences and worldviews represented at Ball State and among those we serve. We promote a culture of respect and civil discourse.

If you need course adaptations or accommodations because of a disability, please contact the instructor of record as soon as possible. Ball State's Disability Services office coordinates services for students with disabilities; documentation of a disability needs to be on file in that office before any accommodations can be provided. Disability Services can be contacted at 765-285-5293 or dsd@bsu.edu.

Disability Services: https://www.bsu.edu/about/administrativeoffices/disability-services

Ball State Academic Ethics Policy

Honesty, trust, and personal responsibility are fundamental attributes of the university community. Academic dishonesty and other forms of academic misconduct threaten the foundation of an institution dedicated to the pursuit of knowledge and will not be tolerated. To maintain its credibility and reputation, and to equitably assign evaluations of scholastic and creative performance, Ball State University is committed to maintaining a climate that upholds and values the highest standards of academic integrity.

Visit the complete Student Academic Ethics Policy.

Plagiarism Policy

Plagiarism is not acceptable. Unless otherwise indicated, you must work independently on all assignments. Sharing of files is not permitted for any reason.

Potential Violations

- Working with another person on any assignment other than authorized group projects.
- Sharing or allowing others to access your files, whether done with permission or not.
- Use or possession of a file created by someone else.
- Reusing work from another semester, course, or section.
- Fraudulent submission of work.
- Using unauthorized materials during exams.
- Impersonating someone else or having them impersonate you.
- Making fraudulent or dishonest statements regarding your work.
- Soliciting others to complete work for you.
- Posting course files and resources on study or content-sharing websites.

The UNC Libraries Plagiarism Tutorial provides a strong foundation in academic integrity.

Plagiarism Detection: The campus subscribes to SimCheck, a plagiarism prevention service integrated with Canvas. Student work is used for plagiarism detection and for no other purpose. A student may notify the instructor in writing that they decline to participate in the plagiarism-detection process, in which case the instructor will use other electronic means to verify the originality of their work.

Proctoring: If any exam in this course is administered online, it will require the Respondus LockDown Browser and Monitor. Instructions for obtaining the software are posted in Canvas.

CANVAS AND STUDENT PRIVACY

Canvas Accessibility

Canvas is designed to be screen-readable and to support accessible content creation through the Rich Content Editor, and holds a National Federation of the Blind Gold Level Web Certification. See the Canvas Voluntary Product Accessibility Template (VPAT) for details.

FERPA and Privacy

Your educational records are confidential under FERPA (Family Educational Rights and Privacy Act) and will not be released without your written and signed consent, except that some directory information may be released unless you file a written request to restrict it. Learn more at Ball State's FERPA and Privacy Protection page.

Video Conferencing Recording

Software may be used to record live class discussions. Recordings are made available only to students enrolled in the class, to support those who cannot attend live or who wish to review content. Students who prefer audio-only participation may disable video; students who prefer to listen only may disable both audio and video. Discuss any concerns with the instructor.

ACADEMIC SUPPORT SERVICES

The Writing Center

All writers improve with practice and feedback. Free appointments (Robert Bell 295, Bracken Library, or online) are available seven days a week — plan ahead, as slots book quickly. Schedule at bsu.edu/writingcenter.

The Learning Center

Free tutoring and academic coaching are available for many Ball State courses, online (Zoom) or in-person (NQ 350). Schedule through TutorTrac at my.bsu.edu, or directly at ballstate.go-redrock.com. Testing accommodations for students with disabilities are available with appropriate documentation from Disability Services. More info at bsu.edu/learningcenter or 765-285-1006.

COURSE SCHEDULE

Module I: The Basics

Synopsis: The basics of Digital Signal Processing, with an acoustics and math review (sigma notation, linear algebra, calculus), plus first projects in the Reaktor® environment.

Tuesday, August 25

- Math review: trigonometry, periodic functions, linear algebra

Thursday, August 27

- Acoustics review: lin/log, sinusoidal motion, digital audio intro

Tuesday, September 1

- Digital audio: discrete vs. continuous time, phenomena of the digital domain, time and frequency domain
- Building simple structures in Reaktor: simple subtractive synthesizer

Reading: Building In Primary, p. 19–33

Thursday, September 3

- The Fourier Theorem: Fourier Transform, convergence
- Building simple structures in Reaktor: using trigonometric functions
- Assignment: Reading Quiz 1

Reading: Acoustics and Psychoacoustics 1.6 — Time and Frequency Domains

Tuesday, September 8

- Lab: building an additive hybrid synthesizer
- Lab: using logarithms to enhance user experience; enhancing controls on the synthesizer
- Assignment: Reading Quiz 2

Project Due: Subtractive and Additive Synthesizer — due Friday, September 11, 2026

Module II: Time Domain Operations

Synopsis: The difference between discrete and continuous time signals; measuring, manipulating, and controlling the time domain; building a compressor/limiter with soft-knee, ratio control, and upward compression.

Thursday, September 10

- Lecture: time-based effects, time shifting
- Lab: creating a delay in the discrete time domain; building a flanger; modulated delay

Reading: Oppenheim, Signals and Systems 1.0–1.1; Factor, Eventide Instant Flanger Manual

Tuesday, September 15

- Lab: pitch vs. time; complex discrete time operations; the simplest low-pass filter

Thursday, September 17

- Lecture: logic functions in DSP
- Lab: building a logic router; compare functions; Boolean logic

Tuesday, September 22

- Measurements in the time domain
- Lab: building time domain effects — limiter, noise gate

Reading: Giannoulis, Massberg, and Reiss — Dynamic Range Compression (JAES 2012); Neumann U473 manual and schematic

Thursday, September 24

- Lab: refining the compressor; building an expander

Tuesday, September 29

- Lab: non-linear vs. linear operations; artifacts of dynamic range compression

Project Due: Compressor / Limiter — due Friday, October 2, 2026

Module III: Digital Filters and the Frequency Domain

Thursday, October 1

- Lecture: filters (IIR/FIR, phase), pass filters, the Z^{-1} at the center of operations

Tuesday, October 6

- Lab: building a pass filter; all-pass filters

Thursday, October 8

- Lab: building a phaser using all-pass; building a vocoder using band-pass

Thursday, October 15

- Lab: building a vocoder (continued)

Note: Fall Break, Oct 12–13 — no Tuesday class this week.

Tuesday, October 20

- Midterm Hackathon

Thursday, October 22

- Midterm Presentations

Module IV: Algorithmic Reverb and Modeling

Synopsis: Applications of the allpass filter, systems with feedback, and building an algorithmic reverb.

Tuesday, October 27

- Lecture: spatial perception
- Lab: applications of the allpass filter, Schroeder allpass sections, systems with feedback

Thursday, October 29

- Lecture: case studies — the Schroeder Reverberator; the Ursa Major Space Station
- Lab: building an algorithmic reverb; modulation and reverb; eigentones and stability

Tuesday, November 3

- Lab: refining and finishing the algorithmic reverb

Project Due: Algorithmic Reverb — due Friday, November 6, 2026

Module V: Data Compression, Source Separation, and AI

Thursday, November 5

- Lecture: audio compression codecs — Fraunhofer, Dolby; how they function

Tuesday, November 10

- Lecture: feature extraction; advanced “next-gen” audio codecs
- Lab: artifacts and issues; determining the quality of a codec

Thursday, November 12

- AI and machine learning in audio

Content determined by the current state of the art at time of teaching.

Module VI: Game Engines and Immersive Environments

Tuesday, November 17

- Lecture: interactive sound

Thursday, November 19

- Lab: sound architecture in Unreal Engine; integrating sounds

Tuesday, November 24

- Lecture: middleware

Note: Thanksgiving Recess, Nov 25–29 — no Thursday class this week.

Tuesday, December 1

- Lab: sound design in FMOD

Thursday, December 3

- Lab: Foley and SFX creation

Project Due: Final Project — due Friday, December 4, 2026

Monday, December 7 — Last day of full-term classes (review / wrap-up, no new content).

December 8–11 — Final Examination Period. See Canvas / the BSU Final Exam Matrix for any section-specific requirements.