Catalog Description:

Extended Description:
This course focuses on approaches to and methods for designing relational and contemporary non-relational (NoSQL) databases. After almost half a century of development, and challenges from various competing paradigms, relational databases remain to be the major paradigm for data persistence. A high-quality relational database can help leverage an organization’s data and information assets for better fulfillment of its mission. On the other hand, a poorly designed database can complicate even the simplest data-driven functions within the organization. This course covers principles and methods for logical and physical database design, the theoretical considerations behind the relational paradigm, as well as SQL, a language for maintaining relational databases and managing data held in relational databases. Once relational database design and administration fundamentals are established, the focus of the course will move to limitations posed by relational databases, and approaches to addressing those limitations within and beyond the relational paradigm, including some of the NoSQL solutions developed over the last decade.

Learning Outcomes:
After completing this course, the student will be able to:
- understand and define fundamental concepts in relational databases,
- develop a logical database design,
- develop entity-relationship diagrams,
- normalize relational database tables,
- develop a physical database based on a logical design,
- perform CRUD (create, read, update, delete) operations on relational databases

Elements of the Course:

Active Participation: The course will involve in-class discussions, as well as in-class exercises. The students are expected to come to class prepared and participate actively. Please inform the instructor in advance if you will not be able to participate in a class meeting.

Preparation Exercises/Questions/Discussion: Most weeks, a number of introductory exercises will be posed, which the students are expected to work on and submit in advance of each class session. Some of the exercises might involve writing queries or other types of code, while others might be discussion questions.

Assignments: Students will work on a number of graded assignments throughout the semester. Students are expected to work on these assignments individually, and not receive any help from classmates or other individuals. Seeking help from the instructor is permitted and advised. If any of the assignment due dates is a holiday for you, please inform the instructor in advance, so an alternate due date can be set for you. Students’ work on and solutions for the assignments will be submitted via Canvas (ELMS) and will be graded. Instructor’s feedback and grades will be posted on Canvas, as well.

Project: Student will work as pairs on a semester-long project where they will develop a logical design for a small-scale, non-trivial relational database, and subsequently implement the design in a physical database. Once the logical and physical design is completed, students will populate their databases with sample data and run CRUD operations on their databases. Students will choose their topic in consultation with the instructor. Project work will begin only after the topic, the scope and other particulars of the project are fully and explicitly approved by the instructor. Students will submit the project deliverables via Canvas (ELMS) for review and grading. Instructor’s feedback and grades will be posted on Canvas, as well.
The following stages of the project will be graded as separate elements:

- Proposal
- Logical design (including an E-R diagram, and normalization as necessary),
- Physical design (including data type choices and queries for building the physical database),
- Sample data and CRUD operations.
- Feasibility analysis of implementing the database on an alternative platform/paradigm.
- Project diary and report (Students will keep a log/diary of their activities on the database, including the challenges faced and how they were solved. A final report will summarize the overall project. The log/diary will be included in the report as a section of an appendix).

The database and the report will be of professional quality, in the sense that they could be used as the basis for an actual relational database in an actual organization. Details about the expectations for the project and submission deadlines will be given on the course website on Canvas.

**Grading:**

<table>
<thead>
<tr>
<th>Category</th>
<th>Percentage</th>
</tr>
</thead>
<tbody>
<tr>
<td>Prep Exercises/Questions/Discussions</td>
<td>10%</td>
</tr>
<tr>
<td>Assignments</td>
<td>25%</td>
</tr>
<tr>
<td>Project - Proposal</td>
<td>5%</td>
</tr>
<tr>
<td>Project - Logical Design</td>
<td>10%</td>
</tr>
<tr>
<td>Project - Physical Design</td>
<td>10%</td>
</tr>
<tr>
<td>Project - Sample Data and CRUD</td>
<td>10%</td>
</tr>
<tr>
<td>Project - Alternative Imp. Analysis</td>
<td>10%</td>
</tr>
<tr>
<td>Project - Project Diary and Report</td>
<td>15%</td>
</tr>
<tr>
<td>Active Participation and Attendance</td>
<td>5%</td>
</tr>
</tbody>
</table>

**Resources:**

**Books (Recommended):**

(Electronic versions of these books might be available for purchase/download. A few chapters from each book will be made available on electronic reserves).

- Murach's MySQL, (2nd ed. OR 3rd ed), Joel Murach,
  Mike Murach & Associates. ISBN: 9781890774820 OR 9781943872367
- **NoSQL Distilled**, Pramod J. Sadalage and Martin Fowler, Addison-Wesley. ISBN: 9780321826626

**Videos:**
A variety of video courses and single videos will be recommended for students who are interested in reinforcing their learning with videos. Most of the videos will be made available through LinkedIn Learning (https://www.linkedin.com/learning/login-ent), Coursera (https://www.coursera.org/), and YouTube. UMD students have free access to LinkedIn Learning, and Coursera videos will be chosen from among freely accessible courses.

**Software (Required - you need both item 1 and item 2 below):**
1) MariaDB Server: A fork of MySQL server that comes as part of the XAMPP distro, which is available at http://apachefriends.org. Download and install XAMPP to deploy MariaDB on your computer. **(Important: Do not download and use the VM version).**
2) MySQL Workbench (Version 6.3.x recommended; the newest 8.0.x version may pose issues during later stages of the course). This is a separate download and install; it does not come with XAMPP. It is available at https://dev.mysql.com/downloads/workbench/6.3.html.

Please install the required software on your computer at your earliest convenience. **You should complete installing the required software by the second class session of the course.** The instructor will help you with installation as needed, but you are responsible for starting the process and getting in touch with the instructor with any issues that may emerge during the installation process.

**A Computer (Required):**
For the best learning experience in this course, you must bring to each class session a fully charged computer that can run the software listed above. **The computer can run on any of the**
common operating systems, such as Windows, MacOS or Linux, as long as it can run the two software applications listed above. The computer should have wireless Internet capability for the best in-class work experience. For the best learning experience, students must refrain from using their computers during class time for activities that are not related to the course.

Additional readings and resources may be assigned as needed. Extra materials will be announced in class and/or via Canvas.
Policy on Academic Misconduct
Cases of academic misconduct will be referred to the Office of Student Conduct irrespective of scope and circumstances, as required by university rules and regulations. It is crucial to understand that the instructors do not have a choice of following other courses of actions in handling these cases. There are severe consequences of academic misconduct, some of which are permanent and reflected on the student’s transcript. For details about procedures governing referrals and possible consequences visit http://osc.umd.edu/OSC/Default.aspx.
It is very important that you complete your own assignments, and do not share any files or other work. The best course of action to take when a student is having problems with an assignment question is to contact the instructor. The instructor will be happy to work with students while they work on the assignments.

University of Maryland Code of Academic Integrity:
"The University of Maryland, College Park has a nationally recognized Code of Academic Integrity, administered by the Student Honor Council. This Code sets standards for academic integrity at Maryland for all undergraduate and graduate students. As a student you are responsible for upholding these standards for this course. It is very important for you to be aware of the consequences of cheating, fabrication, facilitation, and plagiarism. For more information on the Code of Academic Integrity or the Student Honor Council, please visit http://shc.umd.edu/SHC/Default.aspx".

Special Needs
The University is legally obligated to provide appropriate accommodations for students with disabilities. UMD’s Accessibility & Disability Service Office (ADS, https://www.counseling.umd.edu/ads/) works with students and faculty to address a variety of issues ranging from test anxiety to physical and psychological disabilities.
If a student or instructor believes that the student may have a disability, they should consult with ADS (301-314-7682 or adsfrontdesk@umd.edu). Note that to receive accommodations, students must first have their disabilities documented by ADS. The office then prepares an Accommodation Letter for course instructors regarding needed accommodations. Students are responsible for presenting this letter to their instructors.
Students encountering psychological problems that hamper their course work are referred to the Counseling Center (301-314-7651 or http://www.counseling.umd.edu/) for expert help.
<table>
<thead>
<tr>
<th>Date</th>
<th>Topics</th>
<th>Readings (to be done before class)¹,²</th>
<th>Other resources (before class)¹</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 Aug. 26</td>
<td>Course introduction and logistics; Software installation and introduction; SQL introduction; Project ideas</td>
<td>[BDBD] - Ch. 10 [MDBM] - Ch. 6 [SQLVQS] - Ch. 2 [SQLVQS] - Ch. 3</td>
<td>- XAMPP and MySQL Workbench Installation Videos (see Canvas/ELMS for links)</td>
</tr>
<tr>
<td>-- Sep. 2</td>
<td>Labor Day - No Class</td>
<td>---</td>
<td>---</td>
</tr>
<tr>
<td>2 Sep. 9</td>
<td>SQL: Read (<em>R</em>*) operations; Joins; Relationship types; Primary and foreign keys</td>
<td>[MMSQL] - Ch. 4 [MDBM] - Ch. 7 [BDBD] Ch. 9 [SQLVQS] - Ch.s 4, 6, 7, 8</td>
<td>LinkedIn: - Learning SQL Programming - SQL Essential Training - MySQL Essential Training</td>
</tr>
<tr>
<td>3 Sep. 16</td>
<td>SQL: Aggregate (summary) queries; Subqueries; Data types; Functions</td>
<td>[MMSQL] - Ch.s 6, 7 [SQLVQS] - Ch.s 5 [MMSQL] - Ch.s 8, 9</td>
<td>Coursera: - Introduction to SQL (Week 2) (see Canvas/ELMS for links)</td>
</tr>
<tr>
<td>4 Sep. 23</td>
<td>SQL: Create, Update, Delete (C*UD) operations Views</td>
<td>[SQLVQS] - Ch.s 10, 13</td>
<td></td>
</tr>
<tr>
<td>5 Sep. 30</td>
<td>Stored program development; Stored procedures; Stored functions; Triggers; Events; Transactions</td>
<td>[MMSQL] - Ch.s 14, 15, 16 [SQLCE] - Ch. 14</td>
<td></td>
</tr>
<tr>
<td>6 Oct. 7</td>
<td>Entity-relationship diagrams; Defining entities, attributes, and data types; Defining relationships</td>
<td>[DMDLD] - Ch. 2 [RDDCE] - Ch.s 4, 5 [SQLCE] - Ch. 1 [ASQL] Ch. 1</td>
<td></td>
</tr>
<tr>
<td>7 Oct. 14</td>
<td>Normalization</td>
<td>[BDBD] Ch. 8 [DMDLD] - Ch. 6 [RDDCE] - Ch. 6</td>
<td></td>
</tr>
</tbody>
</table>

¹ Except first class.
² Chapters in *italics* will not be available on course reserves due to fair-use limitations.
<table>
<thead>
<tr>
<th>Date</th>
<th>Topics</th>
<th>Readings (to be done before class)¹,²</th>
<th>Other resources (before class)¹</th>
</tr>
</thead>
<tbody>
<tr>
<td>8 Oct. 21</td>
<td>Physical design principles; Indexes; Physical design via MySQL Workbench; Forward and reverse engineering</td>
<td>[FDBMS] - Ch. 8 [MDBM] - Ch. 5 [PDBD] - Ch.s 1, 2 [SQLVQS] - Ch.s 11, 12</td>
<td></td>
</tr>
<tr>
<td>9 Oct. 28</td>
<td>Review week; Relational algebra</td>
<td>[SQLCE] - Ch. 2 [DMDLD] - Ch. 1 [SQLRT] - Ch.s 1, 2, 3</td>
<td></td>
</tr>
<tr>
<td>10 Nov. 4</td>
<td>Limitations of relational databases; New database paradigms; Data models</td>
<td>TBA</td>
<td></td>
</tr>
<tr>
<td>11 Nov. 11</td>
<td>Graph databases</td>
<td>TBA</td>
<td></td>
</tr>
<tr>
<td>12 Nov. 18</td>
<td>Document databases</td>
<td>TBA</td>
<td></td>
</tr>
<tr>
<td>13 Nov. 25</td>
<td>Distribution models; Replication; Partitioning/Sharding; Consistency</td>
<td>TBA</td>
<td></td>
</tr>
<tr>
<td>14 Dec. 2</td>
<td>Derived data; Processing approaches; Data warehousing</td>
<td>TBA</td>
<td></td>
</tr>
<tr>
<td>15 Dec. 9</td>
<td>Review week; Course wrap-up</td>
<td>TBA</td>
<td></td>
</tr>
</tbody>
</table>

¹ Except first class.
² Chapters in *italics* will not be available on course reserves due to fair-use limitations.
**Book Codes:**

**ASQL:** The Art of SQL [2006]
(S. Faroult, P. Robson) (O’Reilly Media - ISBN: 9780596008949)

**BDBD:** Beginning Database Design - 2nd Edition [2012]

**DDIA:** Designing Data-Intensive Applications [2017]
(M. Kleppmann) (O’Reilly Media - ISBN: 9781449373320)

**DMDLD:** Database Modeling and Design: Logical Design - 5th Edition [2011]

**FDBMS:** Fundamentals of Database Management Systems - 2nd Edition [2012]

**MDBM:** Modern Database Management - 10th Edition [2011]

**MMSQL:** Murach’s MySQL - 2nd Edition [2011]

**NSQLD:** NoSQL Distilled [2013]
(Pramod J. Sadalage, Martin Fowler) (Addison Wesley - ISBN: 9780321826626)

**PDBD:** Physical Database Design [2007]
(Sam Lightstone, Toby Teorey, Tom Nadeau) (Morgan Kaufmann - ISBN: 9780123693891)

**PNSQL:** Professional NoSQL [2011]
(Shashank Tiwari) (Wrox - ISBN: 9780470942246)

**RDDDCE:** Relational Database Design and Implementation: Clearly Explained - 3rd Ed. [2009]
(Jan L. Harrington) (Morgan Kaufmann - ISBN: 9780123747303)

**SQLCE:** SQL Clearly Explained - 3rd Edition [2010]
(Jan L. Harrington) (Morgan Kaufmann - ISBN: 9780123756978)

**SQLRT:** SQL and Relational Theory - 2nd Edition [2012]
(C.J. Date) (O’Reilly Media - ISBN: 9781449316402)

**SQLVQS:** SQL Visual QuickStart Guide - 3rd Edition [2008]
(Chris Fehily) (Peachpit - ISBN: 9780321555577)