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6.170 Flipper
Concept Design
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Overview

Motivation

The vision of Flipper is simple: to make the flipped classroom experience an informative and efficient one.

In recent years, flipped classrooms have been more and more prevalent in primary and secondary schools. Students complete readings and video lectures outside of class and spend in-class time working on problems (think 6.042 with Meyer and TEAL). However, due to the infancy of its implementation, the flipped classroom is rather inefficient. In order for a teacher to assess students' completion of assigned reading/videos, the teacher must either collect written responses or administer "nanoquizzes" at the start of class. Both methods have their drawbacks: most teachers already spend 70% of their time on grading, thus collected homework is only checked for completion and not comprehension or correctness and administering nanoquizzes in class is a waste of up to $\frac{1}{6}$ of class time.

Flipper has the following purposes:

- To minimize time in class spent on assessing student's understanding on assigned reading/videos
- To maximize the use of student performance data without increasing the amount of grading required

We will build a system in which teachers can create minilessons for students to complete outside of class. Minilessons will be composed of videos and/or multiple choice questions. They will be organised by subject and assigned within specific classes. Students would then log into their specific accounts to complete the assignment and teacher would then be able to track student participation and understanding of concepts.

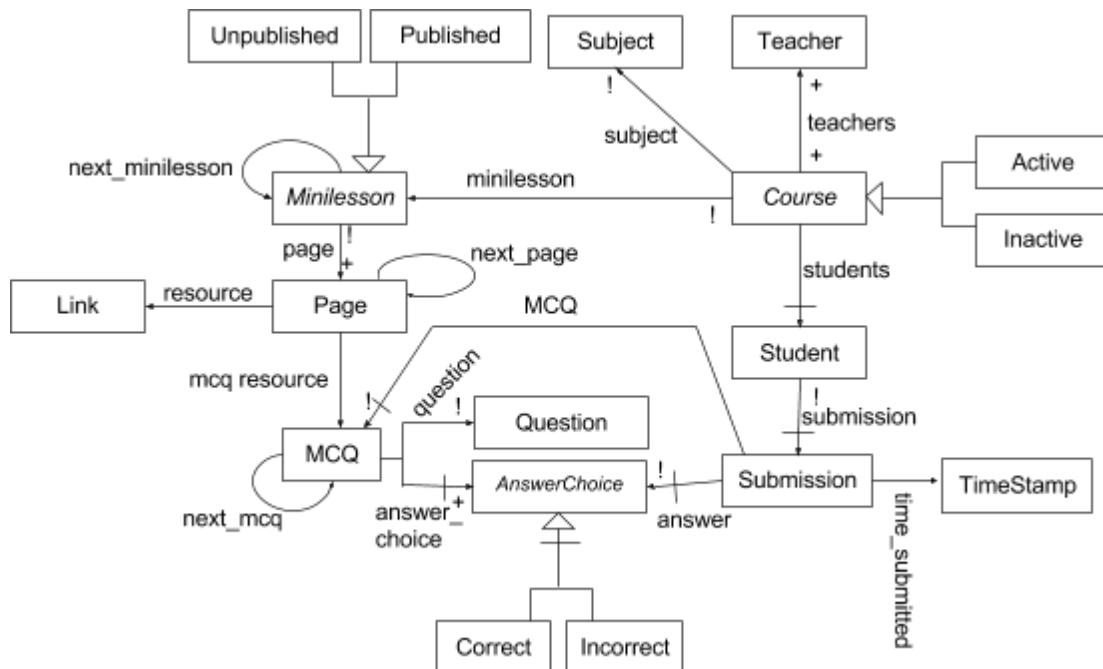
Current similar solutions include Khan Academy and Edx. Khan Academy does not allow teacher and curriculum customisation and Edx is geared towards universities and MOOCs.

Design Essence

Concepts

- List of key concepts with brief definitions
 - Minilesson:
 - definition: a single homework assignment composed of pages
 - purpose: to allow a teacher to assign homework for a specific day, and easily see data on homework, performance.
 - operational principles: if the teacher creates a minilesson for a curriculum, then the students taking the class for this curriculum are able to see the minilesson when logged in and therefore see the associated videos and take quizzes for which the teacher is able to see data on class performance.
 - Page:
 - definition: a single video and MCQs relating to a specific concept
 - purpose: to divide the minilesson in order to create multiple checkoff points and increase pace
 - operational principle: if the teacher divides her minilesson into ordered pages, then when minilesson is viewed, minilesson is displayed/navigable through smaller sections of minilesson, such that MCQ's pertain to only one video.
 - MCQ:
 - definition: the multiple choice question within a page and its placement within a page.
 - purpose: to add ordering to the MCQs within a page and test the user.
 - operational principle: if an MCQ is added to a page of a minilesson, then the specific ordering within the page can be chosen, and such object will be displayed when page is viewed, allowing videos to be viewed and questions to be answered through submissions.
 - Subject
 - definition: topic of class being taught
 - purpose: to be able assign the same combine classes which have the same curriculum.
 - operational principle: if multiple curriculums are of the same subject, it allows the teacher to assign aggregate minilessons to the classes taking these curriculums.
 - Class
 - definition: a grouping of students and teachers
 - purpose: to group students and teachers
 - operational principle: if added as a teacher of a class, then the teacher can assign homework to all the students taking this class and can view their performance.

Data Model



Textual Constraints

- next_minilesson, next_page, and next_mcq can't point to themselves
- Exactly one correct answer choice in each MCQ
- MCQ answer choices are ordered
- Number of answers in each submission must be the same as number of MCQ on the page
- A page must have at least one link of MCQ
- A minilesson is immutable if it is published
- Submissions can only be created for MCQs belonging to published minilessons

Insight

- If teachers were able to edit MCQs within minilessons after they were published, student submissions before the edit would have to be discarded in order to prevent outdated answer references.
- Collaboration across teachers or courses requires making a copy of any minilessons the teachers wish to have in common (sharing a reference to the same minilesson across courses is not possible), and therefore any edits that happen afterwards do not happen across all copies.

Explanation

- Minilesson consists of pages to divide concepts and increase pace
- Pages consist of a resource and MCQ's, which include the content of the assignment
- If a minilesson is unpublished, all of its content is only viewable to the teachers, not students, of the course

Security Concerns

- Assumptions: attackers expect to...
 - deny service for both students and teachers through DDoS attacks;
 - retrieve private information regarding user credentials, course material, including minilesson videos and multiple choice questions, and student responses and performance scores;
 - and hijack existing minilessons/data by modifying private data for malicious purposes
- General Measures
 - Communication
 - The production release of the website will enforce end-to-end encryption by employing TLS and ensure trust by providing a certificate signed by a trusted Certificate Authority.
 - The development release of the website will also enforce end-to-end encryption by employing TLS, but the certificate used will be self-signed for monetary reasons
 - Authentication
 - Strong passwords that meet the following criteria will be required to create and access private data:
 - Leading and trailing spaces will be trimmed off
 - Must contain at least one uppercase and lowercase character from the English alphabet
 - Must contain at least one numeral
 - Must contain at least one special character
 - At least 8 characters in length
 - At most 32 characters in length
 - All passwords will be encrypted and salted using cryptographically secure techniques
 - Validation
 - Any user-generated data submitted to the server will be validated by the browser and by the server
 - Text will be escaped when required
 - Validation of user-generated data will be applied before querying the database
 - SQL or relational databases are not used, so SQL injection is not a threat

- Error messages in the production release will be human-readable and appropriately vague
- Data
 - All private data will be stored in a database that cannot be accessed outside of the server's local network.
 - The server will control and limit access to private data through API's and the authority defined through authentication (i.e. teachers will be able to create/modify minilessons; students will be able to view minilessons and answer questions; and parents will be able to view their children's performances if applicable)
 - Binary data/executables/file uploads will not be accepted
- Rate Limiting
 - Expensive API calls will be rate-limited in order to reduce improper usage and chances of Denial of Service attacks
 - However, we will not implement a system to specifically protect against DDoS attacks
- Preventative Measures
 - XSS
 - *If HTML or any other style of formatting is not supported*
 - HTML written by a user is automatically escaped
 - *If HTML formatting is supported*
 - The text will be run through an HTML sanitization engine that verifies the HTML formatting and controls what HTML will not be automatically escaped
 - CSRF
 - State-changing actions will not employ the HTTP GET verb
 - A CSRF Express middleware will be used (csurf)
 - All state-changing actions that a user can make on the website will be accompanied by a token stored as a cookie
 - When an action is made, the token is added to the HTTP header
 - If an action is made by the website with an invalid token in the HTTP header, then the server will decline the action

User Interface

- Wireframes & Transition diagram attached at the end of PDF.

Challenges

Design Challenges

Concepts

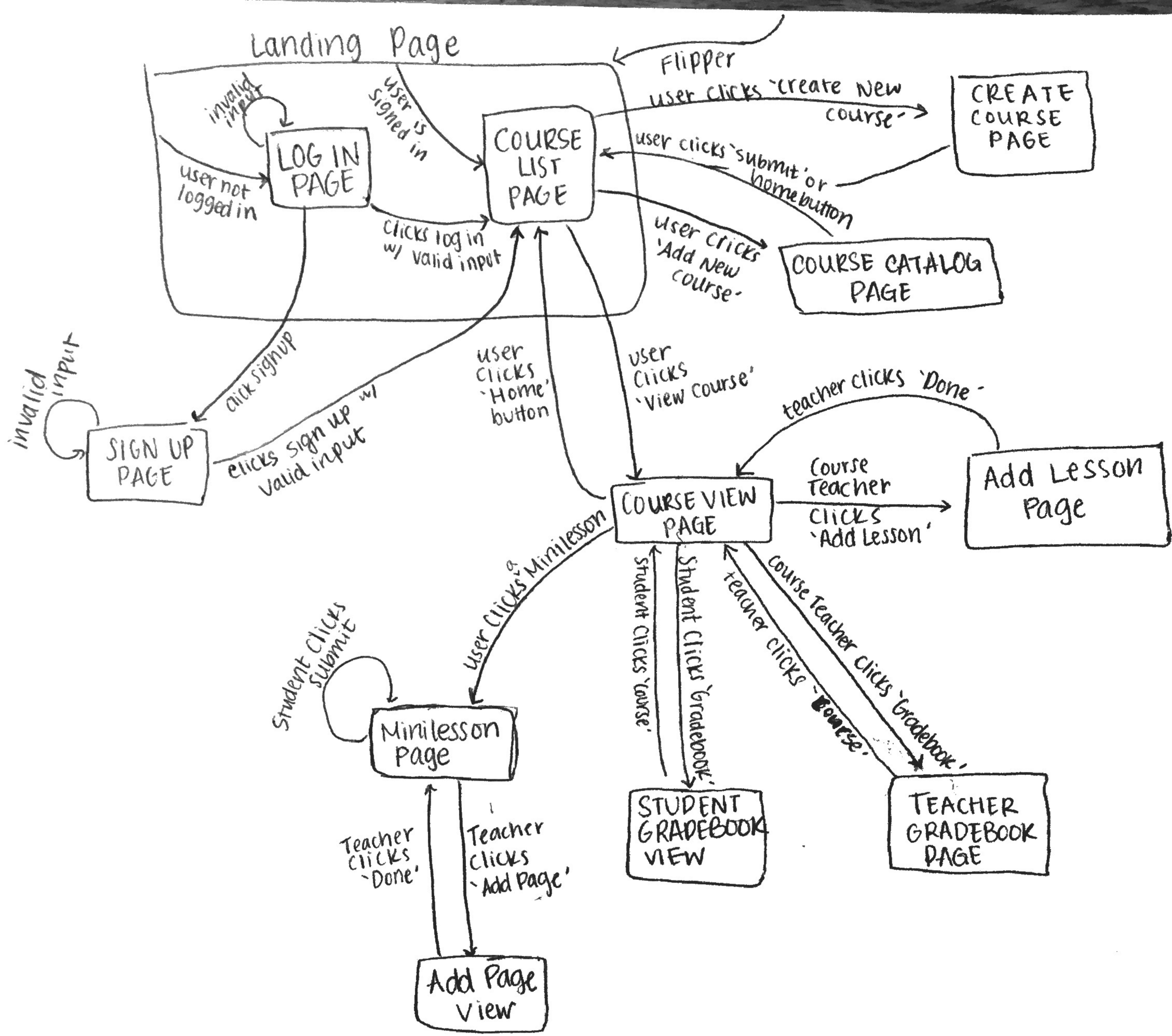
- Version Control
 - Problem: How do we allow a teacher to copy previous year's mini lessons and alter them to assign in current year.
 - Final Decision: We use the concept of curriculum for a subject that keeps track of minilessons. This allows the teacher to take a previous curriculum and alter it to use it for current classes.
- Page and PageObj, defining their differences
 - Problem: How to define the order of object within a page?
 - Final Decision: We opted to create a Page Object that follows other Page Objects. This page object allows Videos and MCQs to have a defined order within a page.

Data Model

- Relationship between subject, curriculum, minilesson and class
 - Problem: how to best represent the relationship between subject, curriculum and class. We had to decide whether we wanted subjects to follow a curriculum or have curriculum belong to subjects and whether classes follow a general curriculum or whether curricula are designed for specific classes, and whether minilessons belonged to individual classes or curricula.
 - Final decision: curriculum belongs to a subject, classes follow a curriculum, and curriculum contains minilessons. This decision was based how classrooms and subjects are viewed traditionally. Teachers may teach many classes that follow the same curriculum, but they may also tweak curricula from year to year. Most curriculum would not span more than one subject.
 - Other options: we considered not having curriculum and instead having minilesson be contained in classes. However, that was not ideal if a teacher wanted to reuse parts of a curriculum easily. In that case, class would have been directly contained under subjects.
- Submission for a page.
 - Problem: How should a student's answers be tracked and how to tell what question is being answered by the student answer?
 - Final decision: We mapped a submission to a page and an answer choices and since all the questions are required to be answered within a page, we know exactly what answer is answering what question, since the questions have a specific order within the page.
 - Other options: saving both the question and answer as pair within the student submission. This was opted against to in favor of space and eliminating redundancy, since the order of questions is already defined within a page.

User Interface

- One type of main view for both teachers & students.
 - Problem: Do we need a separate UI for teachers and students?
 - Final Decision: We created a single user that has the same main course view page, which means a single user can be both a teacher and a student for different courses, we have one login page, and it's a more straightforward implementation.
 - Other Options: A separate login page for both teachers and students, where you specify which type of user you are when you first sign up.
- Summary for Teacher Gradebook
 - Problem: How should teachers be able to aggregate scores across students and lessons?
 - Final Decision: We allowed teachers to have two drop-down menus where they can select a student (or all) and a lesson (or all) to view summary and detailed info.
 - Other Options: A few different gradebook views for teachers, where each one displays different types of stats.
- Students can view answers on page after deadline
 - Problem: Where and how can students view the answers to their submission?
 - Final Decision: After the deadline, we will display the correct answer under the question for each question. This allows a better experience for students.
 - Other Options: Don't display answers (not constructive), immediate feedback (enables cheating more easily), only view answers in Gradebook (more steps for user to go through)



SIGN UP PAGE

Welcome to FLIPPER!

create A Username: _____

create a password: _____

email : _____

Name : _____

institution: _____

SIGN ME UP

Already have an account? **LOG IN HERE**

LOGIN PAGE

Welcome to FLIPPER!

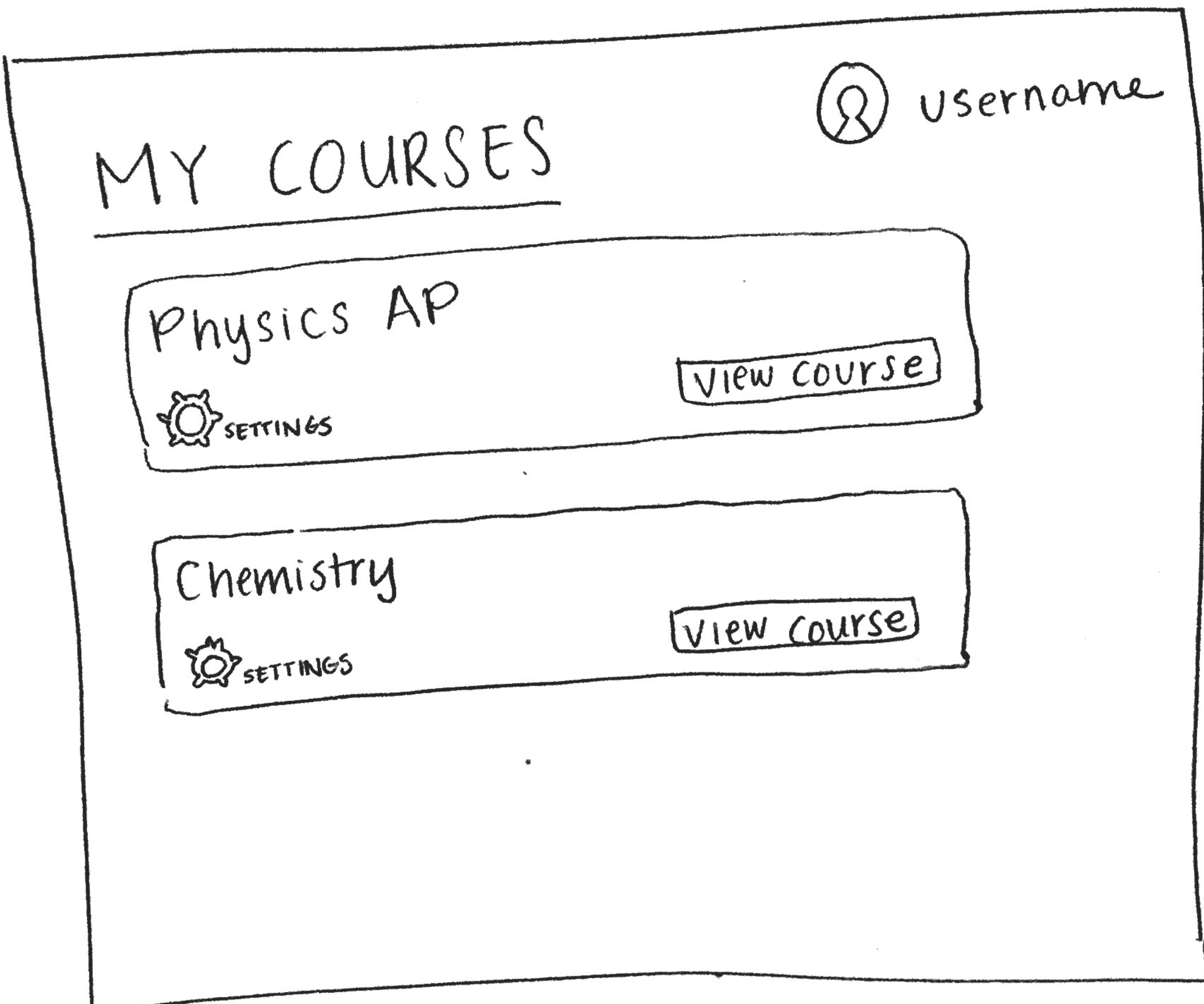
username: _____

password: _____

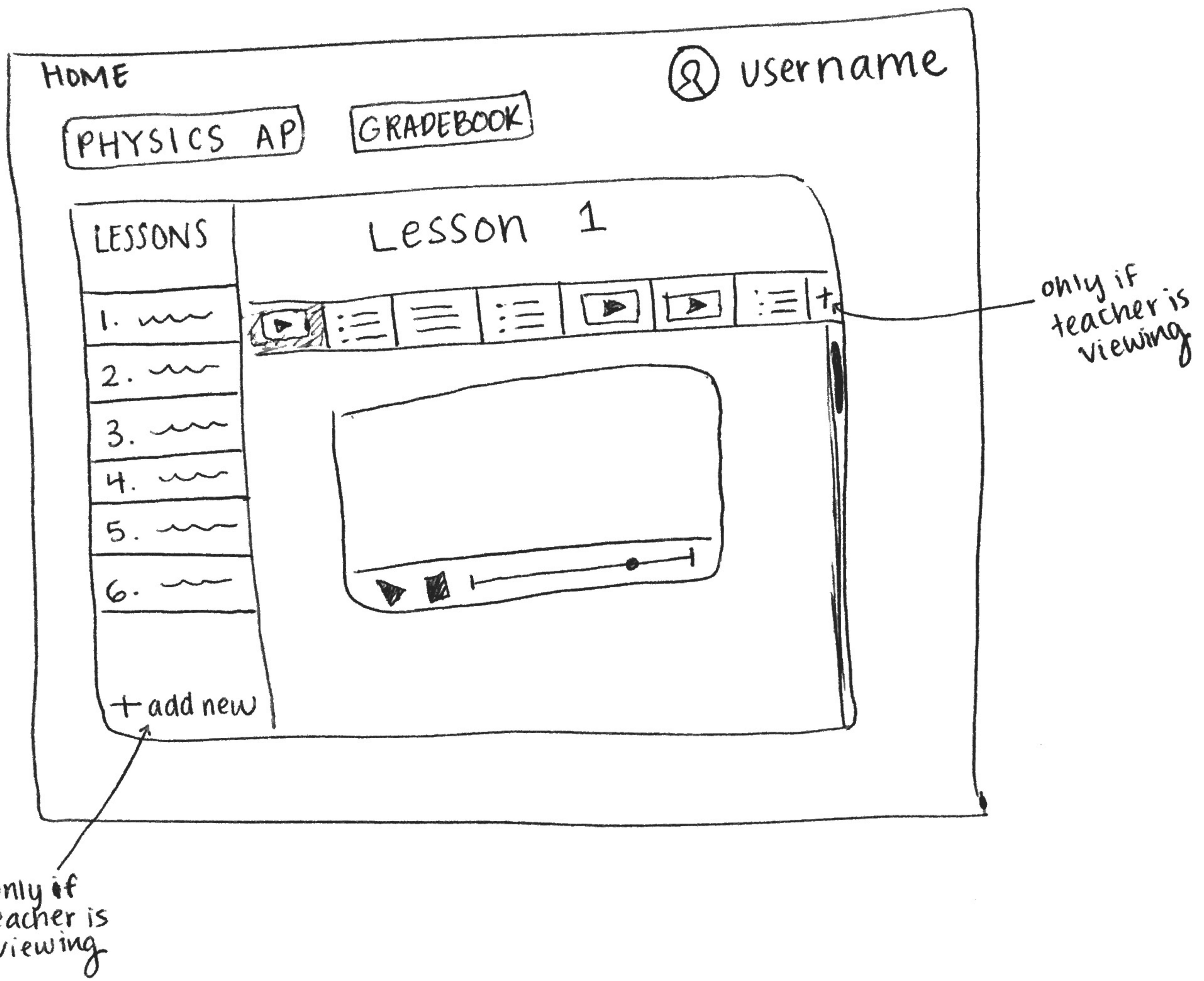
LOG IN

Don't have an account? **SIGN UP**

COURSE LIST PAGE



COURSE PAGE VIEW



COURSE CATALOG PAGE

HOME

👤 Username

Add A Class :

CREATE COURSE PAGE

HOME

@ username

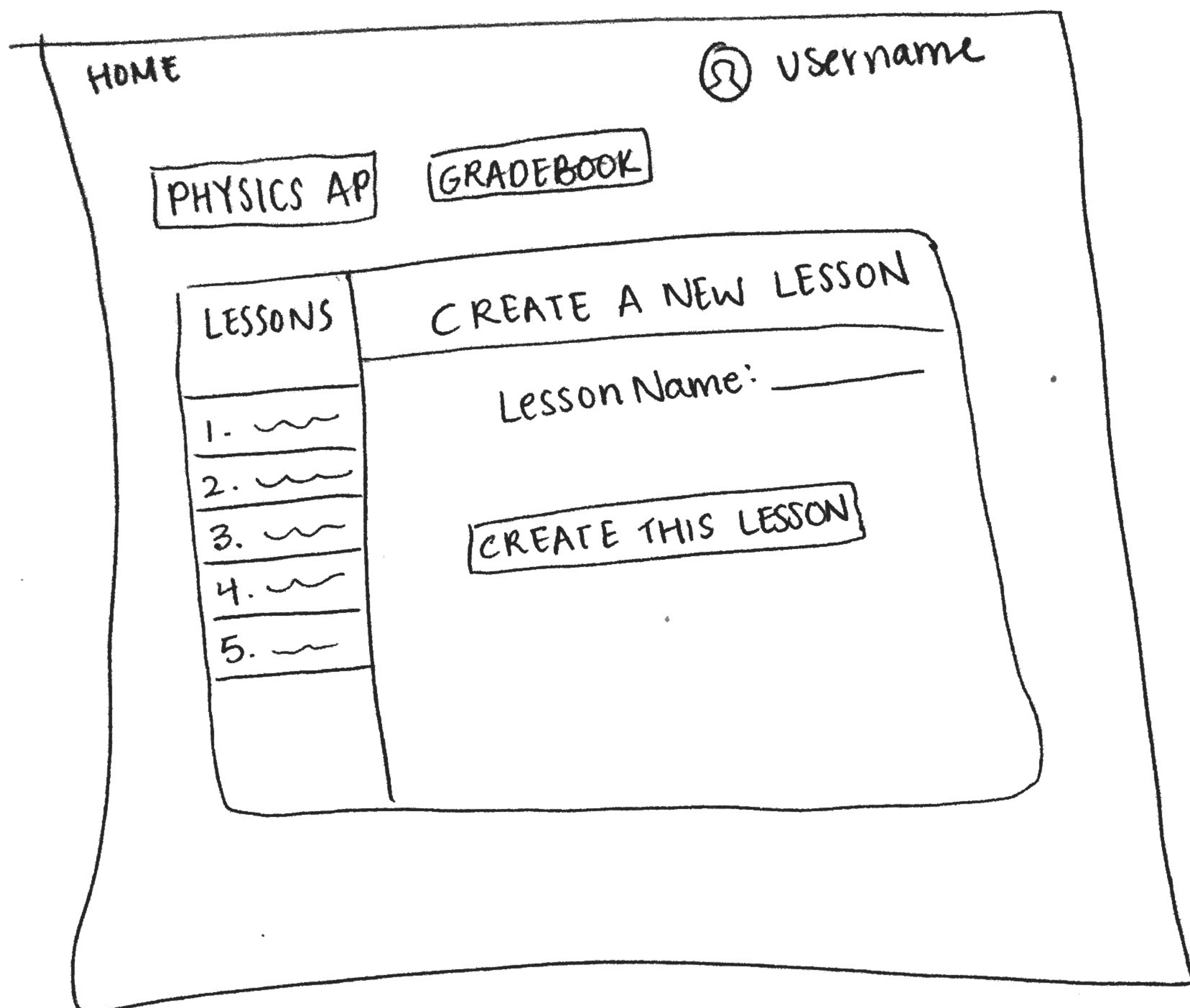
CREATE A NEW COURSE!

Course Name: _____

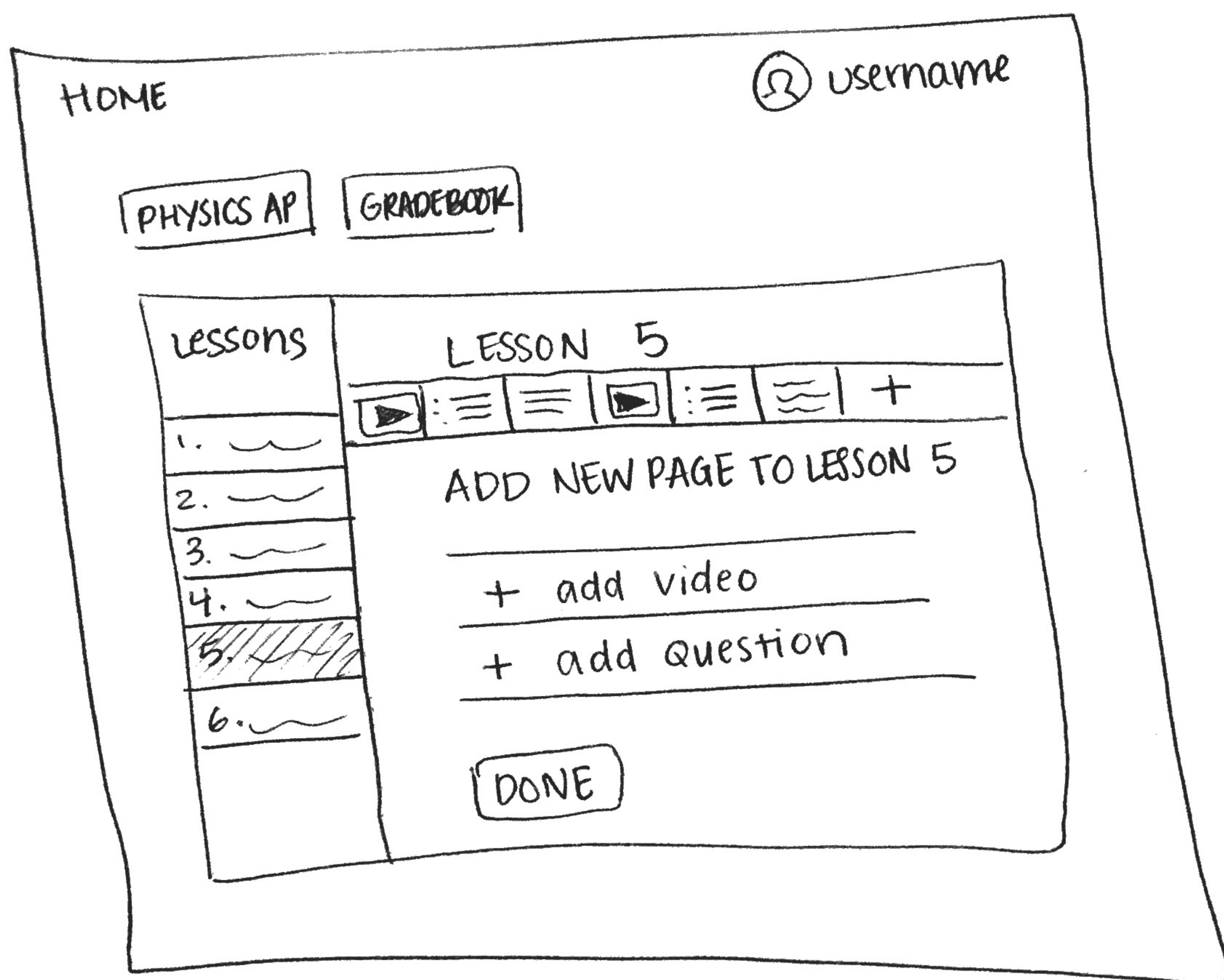
Add Tags: _____

CREATE MY CLASS!

ADD LESSON PAGE



ADD PAGE VIEW



TEACHER GRADEBOOK

HOME

👤 username

PHYSICS AP

GRADEBOOK

Which Student(s) :

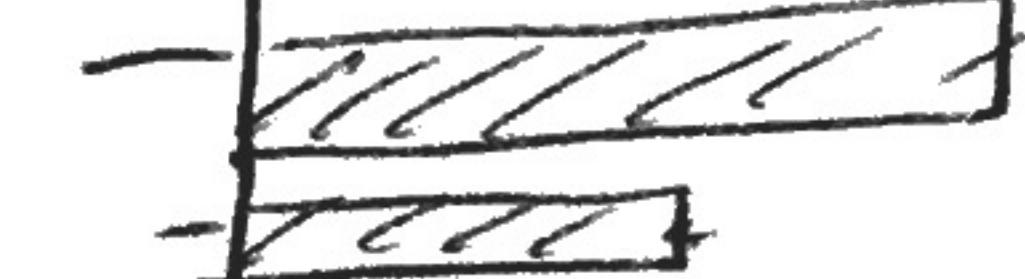
which Lesson(s) :

summary :

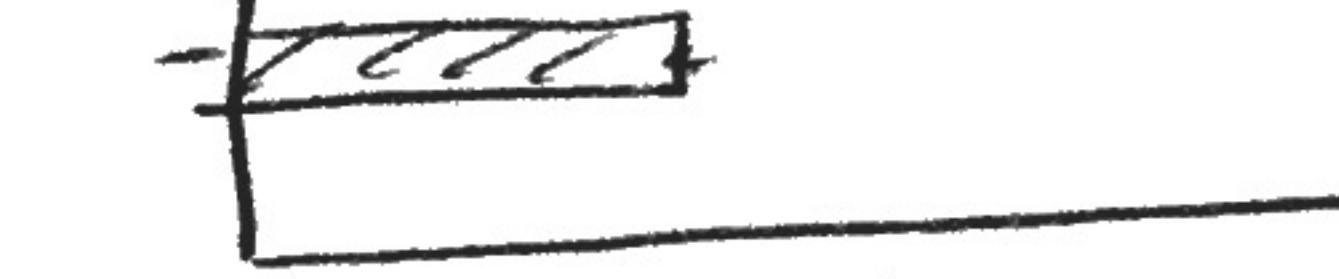
Q1



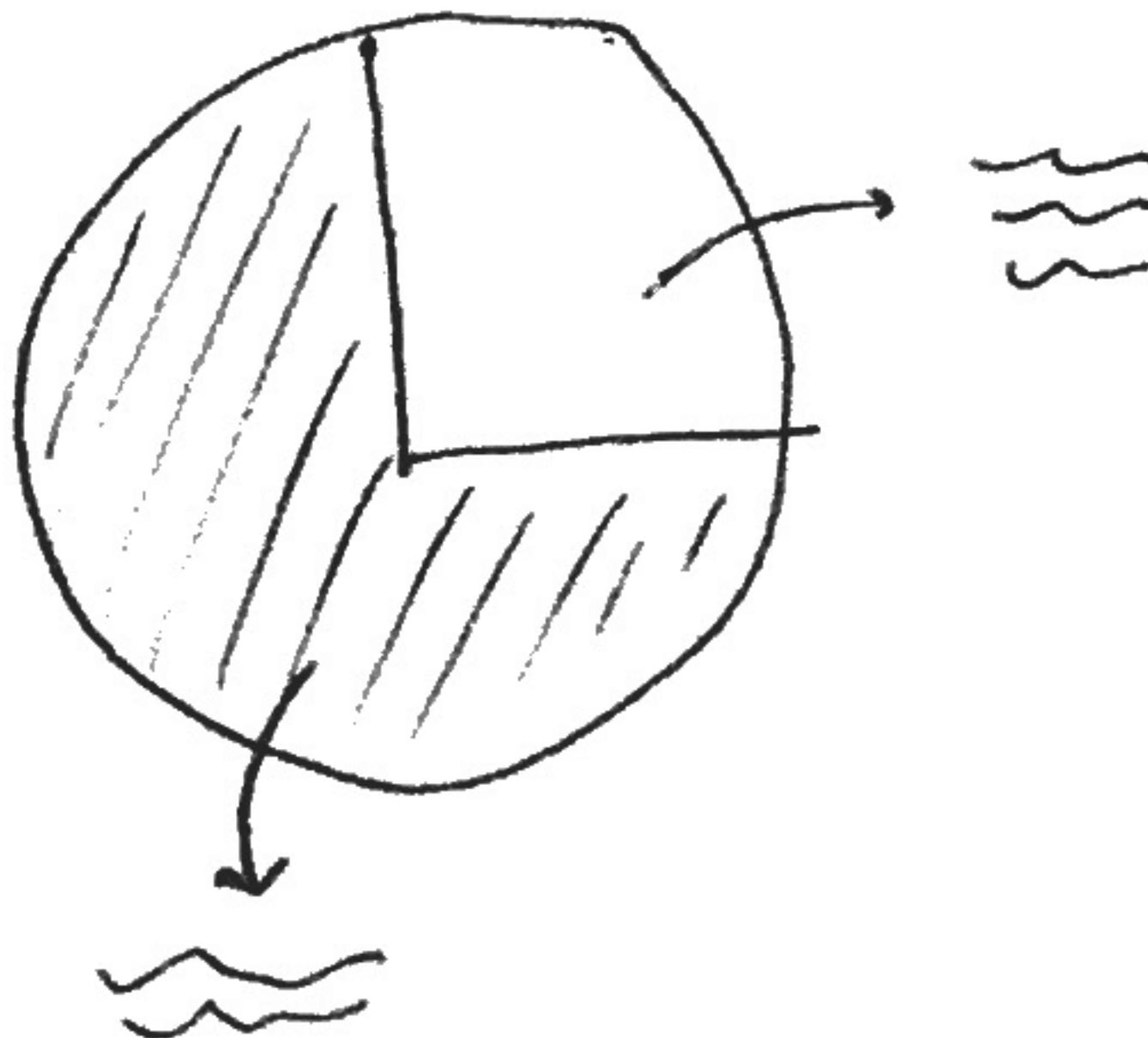
Q2



Q3



% of students
who answered
correctly



STUDENT GRADEBOOK

HOME

PHYSICS AP GRADEBOOK

username

My Grades

Lesson #	Grade	Deadline
1	-	-/-/-
2	-	-/-/-
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