pdfquiz – a TeX CAA system

(Udo Hertrich-Jeromin, 13 September 2006)

Original Problem: Create maths quizzes for M11 students.

Ultimate Hope: Reduce (exam) marking load for large courses.

Achievements (M11, Spring 06):

- Quizzes for students to practice (as part of homework sheets).
- Improved average exam marks (is this related?).
- Reduced homework marking load.

Remaining Problems:

- Can quizzes replace exams?
- How to operate assessed quizzes?
- How to design intelligent questions?

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Examples: Multiple response and numerical questions

Problem 2.1

Tick the statements that you think are correct, or fill in the correct number.

(i) If a subset $A \subset \mathbb{R}$ has the property that $\forall x \in A \exists \eta > 0 : (x - \eta, x + \eta) \subset A$, then A is an open interval.

(ii) Let $f, g : [a, b] \to \mathbb{R}$ be continuous. If $f(a) < g(a)$ and $f(b) > g(b)$, then there exists $z \in (a, b)$ such that $f(z) = g(z)$.

(iii) The polynomial $f(x) = x^5 - 5x^4 + 2x + 1$ has at least two distinct roots in the interval $[-1, 1]$. (Hint).

(iv) Follow the procedure in the proof of the IVT in order to determine the zero of $f : [-1, 1] \to \mathbb{R}$, $f(x) := (4x)^3 - 16x + 1$, up to an accuracy of $\frac{1}{16} = 2 * 2^{-5} = 0.0625$: f has a zero in the interval $(x - \frac{1}{16}, x + \frac{1}{16})$, where $x =$ (input the center of the interval in decimal format).

(v) The zero approximated in (iv) is the only zero of the function in the interval $(-1, 1)$.

Evaluate

▷

Examples: Multiple response and numerical questions

Solution.

(i) This statement is false. Take for example $A = (0,1) \cup (2,3)$. Then it is easy to check that A has the above property, but obviously A is not an interval.

(ii) This is a true statement. Let $h : [a,b] \to \mathbb{R}$ be given by $h = f - g$. Then h is continuous, $h(a) < 0$ and $h(b) > 0$, hence by the IVT there exists $z \in (a,b)$ with $h(z) = 0$, i.e. $f(z) = g(z)$.

(iii) This statement is true. Clearly f is continuous on $[-1,1]$. Now $f(-1) = -9$, $f(0) = 1$ and $f(-1) = 1$, so by the IVT f has a root on $(-1,0)$, and another root on $(0,1)$.

(iv) Following the procedure in the proof of the IVT: our starting interval is $[-1,1]$: we have $f(-1) = -3*16+1 < 0$, $f(1) = 3*16+1 > 0$ so that there must be a zero of f in $(-1,1)$ by the IVT; now we follow the proof:
check $f(0) = 1 > 0$, hence a zero in $(-1,0)$,
check $f(-\frac{1}{2}) = -2^3 + 8 + 1 > 0$, hence a zero in $(-1, -\frac{1}{2})$,
check $f(-\frac{3}{4}) = -3^3 + 12 + 1 < 0$, hence a zero in $(-\frac{3}{4}, -\frac{1}{2})$
check $f(-\frac{5}{8}) = \frac{-125+88}{11} < 0$, hence a zero in $(-\frac{5}{8}, -\frac{1}{2}) = (-\frac{10}{16}, -\frac{8}{16})$,
i.e., $x = -\frac{9}{16} = -0.5625$. (Any x in the interval $(-\frac{10}{16}, -\frac{8}{16})$ is considered correct.)

(v) Check $f(\frac{1}{4}) = -2 < 0$: by the IVT f has two more zeroes, in $(0, \frac{1}{4})$ and in $(\frac{1}{4}, 1)$.

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Examples: Multiple response, different flavour

Problem 8.3

All of the following functions have a differentiable extension to all of $\mathbb{R}$ (make sure that you understand why!). For each function tick the properties you think it has:

	$x \mapsto x^2$	$x \mapsto x^2(1 - \sin \frac{1}{x})$	$x \mapsto \frac{\sin x}{x}$	$x \mapsto \frac{1-\cos x}{x}$
$x = 0$ is a critical point				
0 is a local extremum				
0 is an extremum				
monotone on $(0, \infty)$				
monotone on some $(0, \delta)$				

And, finally, the question: is there a differentiable function $f : \mathbb{R} \to \mathbb{R}$, which has a strict minimum at $x = 0$, is strictly decreasing on $(-\infty, 0)$ but not increasing on any interval $(0, \delta)$, $\delta > 0$?

Evaluate

Design goals

- Simplicity (concentrate on maths, not technicalities)
  - easy for lecturer to design quizzes
  - easy for student to understand the operation
- Flexibility and Portability (use it in different contexts)
  - online/offline operation
  - separation of functionality and layout
  - independence of TeX dialect
- Adaptability (adapt/extend functionality as needed)
  - Open source
  - Clear and easy to understand source code
  - Good technical manuals (PDF & Acrobat JavaScript)

Required Software

- TeX, LaTeX: pdf[la]tex (other pdf drivers possible but not implemented)
- PDF viewer: Acrobat Reader, v5 or higher (viewer needs to understand JavaScript)
- server side: perl or cgi script (optional)

New TEX commands

`\qtick[mu:tu;mc:tc]{app}` — creates a checkbox with appearance app; `mu/mc` are the marks awarded when the box is unchecked/checked and `tu/tc` is the corresponding text shown after evaluation.

Example: `\qtick[3:not checked;-2:box is checked]{$\bigcirc$}` creates the following check box: $\bigcirc$.

`\qnuml[mi:ti;mo:to]`X`(`Δ`)` — creates a number input field; `mi/mo` are the marks awarded if the provided decimal is in/not in $[X-\Delta, X+\Delta]$ and `ti/to` is the corresponding text shown after evaluation.

Example: `(\qnuml[0.5:in interval;1:not in interval]1.3(0.2))` creates the following number input field between the parentheses: (   ).

`\qhint[pm:ht]{app}` — creates a hint with appearance app; `pm` are the penalty marks for requesting the hint and `ht` is the text of the hint, shown in a pop up box.

Example: `\qhint[0.1:this is a hint]{Hint}` produces: Hint.

`\qeval{app}` — creates a button for evaluation with appearance app.

Example: `\underbar{\qeval{Evaluate}}` creates: Evaluate; click on it to evaluate the boxes in the above examples.

Remark: the mark and hint texts are not TEX formatted and should be kept simple.

New TEX commands

`\qtext(wd,ht)[id]{dt}` & `\qline(wd)[id]{dt}` — provide text input fields (for example, for a feedback form); `wd/ht` specify the width/height of the text box (only width in case of the `\qline` command), `dt` specifies a default text to be shown and `id` specifies the name (id) of the text field for reference by the `\qsend` command.

Example: `\underbar{\qline(20em)[feedback]{Your feedback}}` creates the following text input line: ________________________________.

`\qsend[url;fld]{app}` — creates a button with appearance app for submission of the named fields `fld` to a cgi or perl script with URL `url` on a web server.

Example: `\qsend[\url;"feedback","qtotal"]{submit}`, where we let for example `\edef\url{http://www.maths.bath.ac.uk/\string~masuh/cgi-bin/quiz.pl}`, produces: submit.

Remark: a predefined field "`qtotal`" holds an array containing (1) the minutes since opening the document, (2) the maximally available marks, (3) the total marks from all evaluations, (4) the total penalties for requesting hints.

`\qsave{app}` — creates a button with appearance app to save the results of all evaluations.

Example: `\qsave{Save results}` will create: Save results.

Remark: The `\qsend` and `\qsave` commands have not been tested properly and may not work as intended.

New TEX variables

Counters: `\qprbno`, `\qoptno`, `\qnmlno` — these count the problem (a new problem starts after each evaluation) and, in each problem, the checkboxes and number input fields, respectively.

Usage: These counters can be used to automatically number problems or checkboxes within problems; internally these counters are used to identify checkboxes and numerical input fields — therefore these counters should not be tampered with.

Dimensions: `\qmarkwd`, `\qmarkht`, `\qmarkho`, `\qmarkvo` — these control the size (wifth and height) and offset (horizontal and vertical) of the box containing the mark and comment for each checkbox or number input box.

Usage: In order to change the global appearance, change the default values of these dimensions at the beginning of the file; in order to alter the size or position of an individual box, put the new dimensions followed by the corresponding `\qtick` or `\qnuml` command in a group.