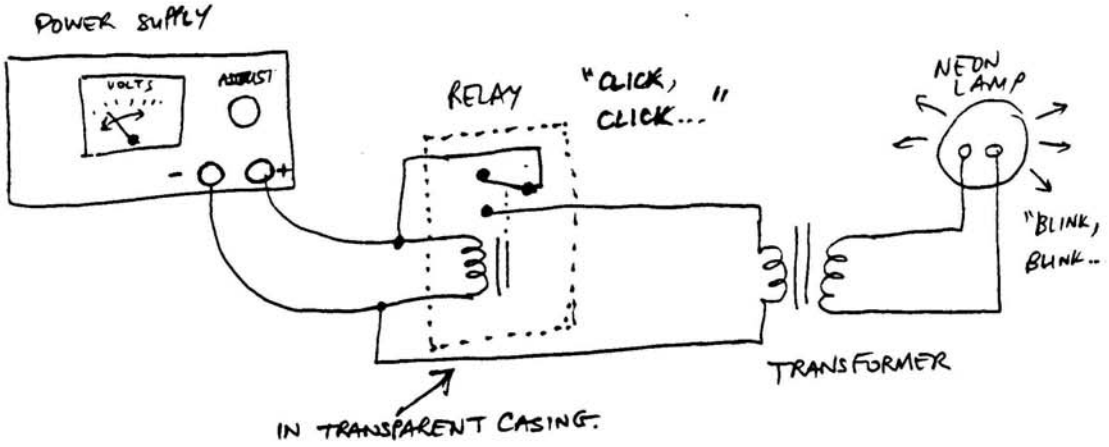
1993 Qualifying Exam Question - G. Kovacs

The philosophy of my question this year was to test the abilities of the student to understand and describe the operation of an extremely simple circuit consisting of three circuit elements known at the turn of the century and a regular, bench-top adjustable D.C. power supply. The point was to see if the student could think on his or her feet, so to speak.

The circuit is shown in schematic form below:



When the power was turned on, the circuit oscillated, producing audible "clicks" of the relay and visible flashes of the neon lamp. The analog voltmeter on the power supply could also be seen to be oscillating between its "unloaded" voltage and a lower voltage.

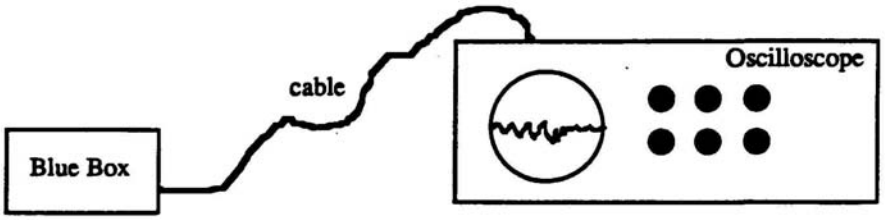
The relay used was encased in transparent plastic, the wiring was simple (only 5 wires) and the entire setup was in plain view.

The operation of the circuit is best described as:
1) The relay, connected across the outputs of the power supply is energized and closes.
2) The transformer is then placed in parallel with the coil of the relay.
3) This current pulse on the primary of the transformer creates a higher voltage pulse on the secondary which lights the neon lamp transiently.
4) The additional load of the transformer on the power supply causes the voltage to drop, forcing the relay to open.
5) The cycle repeats.

The student did not need to discuss the secondary circuit (e.g. neon lamp) in any way, and was told that it did not affect the oscillations of the circuit.

G. Kovacs' QUALS QUESTION JAN 1994 Circuits

The student was asked to sit down in front of an oscilloscope displaying a signal coming from a blue plastic box in front of it. A brief, but carefully-prepared set of instructions was read, instructing the student that they were to focus on the blue box, that playing with the oscilloscope controls was allowed but would only waste time (they were preset correctly) and that without "smashing, disassembling or setting fire to" the blue box, they should tell me as much as possible about its contents.



Time was allowed for the student to study the situation and if they had not touched the box within a couple of minutes, they were prompted to do so. Along the way, they were asked to describe the waveform seen on the oscilloscope when the box was not being moved (noise) and whether or not they could tell if the circuit within the blue box was active or passive based only on the signal displayed (the approach to answering the latter question was more important than the answer -> active).

Once the student had played with the device, they were asked to try to describe its contents and, if needed, were given hints to describe the quantity the box might be measuring (it contained an accelerometer). The student's approach to the problem was most important.

Once the student had established that it was an accelerometer of some type, they were asked to determine its sensitivity in volts per "g" (unit of gravity). Various solutions were possible, such as observing that the sensor had a DC response, so turning it upside down causes a variation of a known acceleration, etc., etc.

The student was then asked to estimate the noise level and give some examples of uses of accelerometers "in the real world."

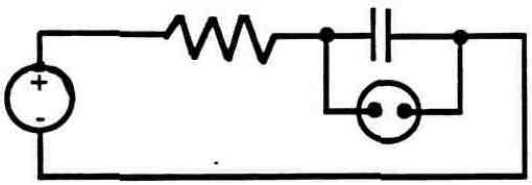
Finally, the student was asked to think about a "generic" device to measure acceleration and explain what basic elements it would require (i.e. a mass to be accelerated, a restoring force of some kind and a transducer to measure the force or position and convert it into an electrical signal.

G. KOVACS' QUALS QUESTION JAN 1995

circuits

This question involved oscillators built using gas discharge lamps. The objective of the examination was only partly to see if the student could correctly answer the questions posed... equally important was the student's approach.

The basic circuit employed was as follows:



The voltage applied to the circuit was provided by a DC-to-DC converter running off a low-voltage, adjustable DC laboratory supply. The student was told of this and it was pointed out that the DC-to-DC converter had nothing to do with the phenomena to be discussed. The voltage applied to the circuit was displayed using a digital multimeter so that the student realized that it was > 80 V.

Several of the circuits as shown above were assembled in a stack. The neon lamps were flashing (each at a steady rate) and the student was asked to explain the operation of the circuit. This explanation was facilitated by the available information, including the measured applied voltage, clues provided during the exam, and the student's observations (looking at the physical circuit was helpful!). Knowing the exact component values was not necessary.

The mechanism is that the capacitor charges up to the discharge voltage of the neon lamp, at which point it stays lit as the capacitor discharges down to a substantially lower voltage (where it can no longer maintain a discharge). The capacitor then charges up to the discharge voltage and the cycle repeats.

The student was then instructed to look at another similar circuit with an LED in series with the neon lamp and explain why the LED was flashing (simply because the current was gated by the neon lamp).

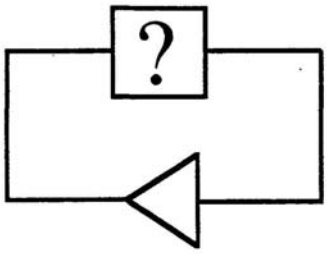
Finally, the student was asked to look at a circuit wherein an LED (the fact that it was some kind of LED was either already clear to the student or was pointed out) was flashing in a similar circuit. The question was whether or not one could construct such an oscillator from an **ordinary** pn junction diode (such as an LED), a capacitor and a resistor. The point here was to see if the student understood how such oscillators might work and whether he or she believed what they were seeing or what they knew to be correct.

Again, the student's approach to the problem was most important.

G. KOVACS' QUALS QUESTION JAN 1996

This question involved a physical/electronic feedback circuit and was intended to help provide insight into the examinee's thinking processes.

The examinee was seated in front of an assemblage of electronic equipment, and their attention was specifically directed toward a small region containing a (full) can of beer with some objects glued onto opposite sides. The student was told that the system was a feedback loop. An oscilloscope in the apparatus displayed a flat line, representing a sample of the signal somewhere in the loop. The loop looked like (question mark representing the region the student was asked to look at):



The examinee was shown that when the amplifier gain was increased, oscillations began in the loop. The question posed was to explain, physically, how the oscillations occurred, paying particular attention to the region of the apparatus around the beer can.

The examinee was free to physically investigate the region of the apparatus in question, but was instructed to ask before touching anything.

The apparatus consisted of an ordinary metal nut glued to one side of the beer can and positioned close to the pole piece of an electromagnet. On the opposite side of the beer can was an accelerometer, also glued to the beer can, and providing feedback for the loop. The output of the amplifier was applied to the electromagnet, which could pull on the nut, thus slightly deforming the beer can. The mechanism of oscillation was that, with sufficient amplifier gain, the beer can could be driven into resonance.

By physically interacting with the apparatus and asking questions, the examinee was potentially able to deduce the nature of the oscillator.

The student's *approach* to the problem was most important.

Date: Tue, 4 Feb 1997 13:17:45 -0800 (PST)
From: Greg Kovacs <kovacs@cis.Stanford.EDU>
To: shankle@ee.stanford.edu
Subject: Re: Quals Questions 1997

circuits (?)

Diane,
Here is my quals question.
Thanks,
Greg

G. Kovacs Quals Question 1997

The student was asked to put on a pair of glasses and look at a multi-colored image. The question was to try to explain the mechanisms underlying the perceived three-dimensional effect, which was based on a wavelength-dependent light bending effect of the optics in the glasses (like a prism). The point of the question was to observe the way the student looked at/used the available information, proposed and carried out simple experiments, and maintained an organized and logical path to his or her conclusions.

Subject: Re: Quals Meeting Reminder
Date: Fri, 23 Jan 98 20:48:46 -0800
From: Gregory Kovacs <kovacs@cis.Stanford.EDU>
To: "Diane Shankle" <shankle@ee.Stanford.EDU>
Mime-Version: 1.0
Status:

Circuits

Diane,
Sorry that I couldn't attend. Here is my question.

Thanks,
Greg

G. Kovacs Quals Question 1997/98

Question: The student was given four cylindrical plastic containers filled with four different substances. They were asked to provide as much information as possible about their contents without opening them.

Answer: There was no correct or incorrect answer. The evaluation was based on the methods used, clarity of thinking and approach of the student.

>Qual's Meeting
>Friday, January 23, 1998
>3:30 P.M.
>Durand 450
>
>Please bring a copy of your Qual's question and answer to the meeting.
>
>Thanks!
>Diane
>
>
>

Subject: Re: Quals Question 2001
Date: Fri, 16 Feb 2001 16:32:06 -0700
From: Greg Kovacs <kovacs@cis.stanford.edu>
To: "Diane Shankle" <shankle@ee.stanford.edu>

The student was asked to sit at a table with several objects on it. He or she was told that a device on the table was a sensor of some kind, and that it was sensing something about a glowing cylinder also on the table. Also on the table were various items (paper, pen, hardcover book, sheet of copper-clad printed circuit board, toilet paper roll, full beverage can, and a plastic ruler). The student was told that he or she could touch and use these items at will. The student was allowed to move and examine everything on he table, except for the sensor (because it is delicate). It was stated that the sensor could detect something to do with (emitted by) the glowing cylinder, and the student was asked to try to figure out what (as specifically as possible) was being sensed (e.g., what the sensor detects from the glowing rod). The various objects on the table could be used to carry out a variety of simple experiments to obtain information about the signal and the sensor.

Sorry - I thought I had submitted it.

Best,
Greg

>I am still waiting for you to submit your Quals Question either by hard copy
>or email.
>Please try to submit by 2/23/01.
>
>Happy Thursday,
>Diane
>

G. Kovacs' Quals Question – 2001/2002

The student was asked to sketch the design, on paper, of an analog circuit (amplifier, oscillator, filter, etc.) that used three NPN bipolar transistors and any passive components the student wished. The student was told that it was up to them to choose the circuit parameters. It was requested that the circuit not be overly complex, and that the exact component values were not wanted – rather, the student was asked to discuss the design process. Students who were not familiar with BJT's were told that they should design with MOS transistors and the examiner would help them "translate" their design. The student was told that giving rough design equations would be helpful, but that it was key to explain the desired properties and operation of the circuit.

To: Gregory Kovacs <kovacs@cis.stanford.edu>
From: Diane Shankle <shankle@ee.stanford.edu>
Subject: Re: Quals Question 2003
Cc:
Bcc:
X-Attachments:

Greg Kovacs Quals Question 2003

The student was shown a schematic for a basic, no-tricks common-emitter amplifier using an NPN bipolar transistor. They were asked to determine the gain of the circuit from the information provided, which was fully adequate.

If finished in time, the student was shown an inverting op-amp circuit with a small-signal input signal and an offset voltage added to the positive op-amp terminal. The student was told the amplifier and all components were ideal, and asked to describe the output signal as accurately as possible.

If finished in time, the student was shown an op-amp voltage follower and a configuration with the positive input terminal tied to the output. The student was asked to comment in general terms on the behavior of the two circuits.

G. Kovacs Quals Question 2005

The student is told about self-flashing LED's, which are explained using a block diagram. The LED consists of a standard LED light emitting chip and a CMOS chip that generates a squarewave of current through the LED alternating between zero and twenty milliamps. The student is then asked to think about 100 of the same blinking LEDs wired in parallel, with the total current from all 100 flowing to ground through a 0.1 Ohm resistor. The student is asked to sketch the voltage waveform at the node between the resistor and the negative terminals of the blinking LEDs from time zero to a minute or so.

The student is then shown the actual waveform from the circuit. They are asked to compare to their sketch and explain any differences.

The student is then asked to consider the power spectrum of the signal presented to them over a minute or so. The emphasis is not on minute detail, but understanding how large-scale changes in the waveform over this time would manifest in changes in the power spectrum.

The student is then shown the actual power spectrum and asked to compare their sketch or comments to it and comment.

Date: Sun, 05 Mar 2006 20:43:16 -0800
Subject: Re: Reminder Quals Question 2006
From: Gregory Kovacs <kovacs@cis.stanford.edu>
To: Diane Shankle <shankle@ee.Stanford.EDU>

Diane,
Here you go.

Best,
Greg

G. Kovacs Quals Question 2006

Area: Circuits

The student was shown a schematic depicting two components, an N-channel power MOSFET and an inductor, in series, with the inductor tied between a positive supply voltage and the drain of the MOSFET. The student was offered the MOSFET datasheet. The source of the MOSFET was grounded. The gate was driven by a squarewave of sufficient amplitude to fully turn the MOSFET "on" and "off." He or she was asked to describe the operation of the circuit and predict the output voltage waveform. The student was then shown actual oscilloscope photographs of the circuit in operation and asked to compare his/her predictions to what was actually observed.

On 3/1/06 8:58 AM, "Diane Shankle" <shankle@ee.Stanford.EDU> wrote:

> Hi,
>
> Reminder!
>
> Please send me your Quals question.
>
> Thanks and Enjoy Your Day,
> Diane

2012 Quals question:

Students were asked to examine a simple electronic circuit consisting of six commercially available components. The circuit produced rhythmic flashes of light and students were asked to explain the operation of the circuit.

Thanks,
Greg Kovacs

Quals Question 2013
Greg Kovacs

You have been asked by your boss to evaluate a circuit board. She needs you to figure out as much as you can about it in ten minutes and leave her with a one-page written report on the form provided. You may not modify, power-down, break, or pull components from the circuit.