The following table gives the number of respondents who obtained each score. 22 of 40 took the quiz.

score	13	12	11	10	9	8
number	1	5	4	6	2	4

The numbers in parentheses below show the number of people who missed each question.

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1. Recall:

   - A TM is *total* if it halts on all inputs
   - A set is *r.e.* if it is $L(M)$ for some TM M
   - A set is *recursive* if it is $L(M)$ for some total TM M
   - The *halting problem* is the set

   $$\text{HP} = \{M\#x \mid M \text{ is a TM, } x \text{ is a string over } M\text{'s input alphabet, } M \text{ halts on input } x\}.$$

   True or false?

   (i) Every CFL is recursive. **true (1)**

   (ii) There exists a recursive set that is not a CFL. **true (1)**

   (iii) All recursive sets are r.e. **true (3)**

   (iv) $\{a^p \mid p \text{ is a prime number}\}$ is a recursive set. **true (3)**

   (v) If $L(M)$ is recursive, then M is total. **false (10) A machine can loop and still accept a recursive set. For example, a machine that loops on all inputs accepts $\varnothing$. For a set to be recursive, there must *exist* a total machine accepting it.**

   (vi) If M is total, then $L(M)$ is recursive. **true (0)**

   (vii) TMs with two tapes accept more sets than TMs with one tape. **false (1)**

   (viii) Every Turing machine accepts a nonregular set. **false (1)**

   (ix) It is decidable for a given TM M and string x whether M accepts x. **false (6)**

   (x) It is decidable for a given TM M whether $L(M) = \sim\text{HP}$. ($\sim$ denotes set complement.) **true (17)** $\sim$HP **is not r.e., so the answer is always "no".**

2. In the following TM, the input alphabet is $\{a, b\}$, the left endmarker is $\vdash$, and the blank symbol is $\sqcup$. The transitions are given in the following table.

		$\vdash$	a	b	$\sqcup$
start state $\rightarrow$	s	$s, \vdash, R$	t, b, L	r, a, L	$s, \sqcup, L$
accept state $\rightarrow$	t	$t, \vdash, R$	t, b, L	t, a, L	$t, \sqcup, L$
reject state $\rightarrow$	r	$r, \vdash, R$	r, b, L	r, a, L	$r, \sqcup, L$

   What language does it accept?

   (a) strings beginning with a **(1)**

   (b) strings containing only a's

   (c) strings containing at least one a

3. True or false?

   (i) The machine of question 2 is total. **false (8) The machine loops on input ε.**

   (ii) The language accepted by the machine of question 2 is recursive. **true (7)**