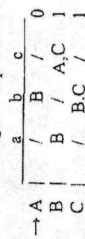


Wednesday, July 2, 2008, 2 - 5 pm

Open Book and Notes Final grades only through PeopleSoft

**YOU MUST USE THE CONSTRUCTIONS GIVEN IN CLASS**

1. Construct a regular expression over  $\{a, b, c\}$  for the language accepted by this nfa:



2. Prove that the language  $L(G)$  is not regular where  $G$  is the following cfg:

 $G = (\{S, A, B, C\}, \{a, b, c\}, \{S \rightarrow AaB(C, A \rightarrow aS, B \rightarrow a, C \rightarrow b), S\}$ 

Note: You must first determine  $L(G)$ .

3. Construct a reduced dfa for the following extended regular expression over  $\{0, 1, 2\}$ :

$$[(100^*1)^* \cap 1^*]$$

Note: You must first determine nfas for  $(100^*1)^*$  and  $1^*$ , then do the intersection. The answer must then be reduced.

4. Construct a Chomsky normal form grammar for  $L(G)$  for the following cfg:

 $G = (\{S, B\}, \{a, b, c, d\}, \{S \rightarrow SaSbcbBa, B \rightarrow cbBd(S)c\}, S)$ 

Note: You must first remove all  $\epsilon$ - and all unit productions.

5. Construct a Greibach normal form grammar for  $L(G)$  for the following CNF  $G$ :

 $G = (\{S, A\}, \{a, d\}, \{S \rightarrow AS(A)d, A \rightarrow SS(a), S\})$ 

Note: You must first remove all unit productions. You must derive all the productions for  $S$  and  $A$ ; indicate how the result looks for  $S'$  and  $A'$  as applicable.

6. Prove that the following language  $L$  is not contextfree:  $L = \{0^{n+1}1^{n-1}0^n \mid n > 0\}$ .

7. Consider the class  $\mathcal{L}_A$  of all contextfree languages over the fixed alphabet  $A$ .

(a) Is  $\mathcal{L}_A$  countable?

(b) Is the class  $\mathcal{M}_A$  countable where  $\mathcal{M}_A$  consists of all languages over  $A$  that are not in  $\mathcal{L}_A$ ?

(c) Is the class  $\mathcal{L}_A \cap \mathcal{M}_A$  countable?

For each question, you must give a precise argument substantiating your answer.

8. Construct a Turing machine for the language in Question 6,  $L = \{0^{n+1}1^{n-1}0^n \mid n > 0\}$ .

Note: Describe first the process in English; then translate this into moves of the Turing machine.

9. Let  $L_1$  and  $L_2$  be arbitrary languages, subject to the specification in either (i) or (ii). Consider the following four general questions:

(Q1) Does  $L_1 \cup L_2$  contain a given fixed word  $w$ ? (Q2) Is  $L_1 \cup L_2$  non-empty?

(Q3) Does  $L_1 \cap L_2$  contain a given fixed word  $w$ ? (Q4) Is  $L_1 \cap L_2$  non-empty?

For each of these four questions explain with reasons whether the problem is recursive, not recursive but r.e., or non-r.e., provided

(i) Both  $L_1$  and  $L_2$  are recursive. (ii) Both  $L_1$  and  $L_2$  are r.e., but not recursive.

Points: 1: 6 2: 8 3: 14 4: 12 5: 12 6: 12 7: 13 8: 8 9: 15

$$1 \quad A \rightarrow bB$$

$$B \rightarrow aB \vee cA \vee cC \vee \epsilon$$

$$\rightarrow a^i c(A \cup C) \cup a^i$$

$$C \rightarrow bB \vee bC \vee \epsilon$$

$$\rightarrow b^i b B \vee b^i$$

$$B \rightarrow a^i c A \vee a^i c b B \vee a^i c b^i B \vee a^i c b^i a^i$$

$$\rightarrow (a^i c b^i a^i c b^i) \cup a^i c A \vee (a^i c b^i a^i c b^i) \cup (a^i c b^i a^i)$$

$$A \rightarrow b(a^i c b^i a^i c b^i) \cup a^i c A \vee b(a^i c b^i a^i c b^i) \cup (a^i c b^i a^i)$$

$$\rightarrow [b(a^i c b^i a^i c b^i) \cup a^i c] b(a^i c b^i a^i c b^i) \cup (a^i c b^i a^i)$$

$$2 \quad S \rightarrow AaB \mid C$$

$$A \rightarrow aS$$

$$B \rightarrow a$$

$$C \rightarrow b$$

$$S \rightarrow aSa \mid a \mid b \quad L(G) = \{a^i (a \cup b)^i a \mid a \in \{0\}\}$$

Assume that  $L$  is regular: it is accepted by some DFA  $R$ .

$R$  has  $n$  states. Choose  $x = a^n b a^n c \in L$ .

$x$  is long enough: it can be pumped  $w^n a^n b a^n$ .

$w^n a^n b a^n$  for  $n \geq 0$  and  $\forall z \geq 0$  if  $w, w', u, c \in L$ .

Choose  $s = 2$  a contradiction:  $a^n b a^n c \in L$  is not regular.

$$3 \begin{bmatrix} (100)^T A^T \end{bmatrix} = \begin{bmatrix} (100)^T v^T \end{bmatrix}$$

0	1	2	0	1	2	0	1	2
-0	/	/	/	/	/	-0	/	/
1	2	/	/	0	1	1	4	/
2	/	/	1	2	/	4	/	/

0	1	2	0	1	2
-0	/	/	/	/	/
1	2	/	1	4	/
2	/	/	2	/	/

A	B	C	D
A	B	C	D
A	B	C	D
A	B	C	D

0	1	2	0	1	2
-0	/	/	-0	/	/
1	2	/	1	4	/
2	/	/	2	/	/

0	1	2	0	1	2
-0	/	/	-0	/	/
1	2	/	1	4	/
2	/	/	2	/	/

$$4 \quad S \rightarrow S_a S_b c \mid B_a$$

$$B \rightarrow c B_d \mid S \mid \epsilon$$

$$S \rightarrow S_a S_b c \mid B_a \mid a$$

$$B \rightarrow c B_d \mid c S_d \mid c d$$

$$S \rightarrow S_a S_b c \mid B_a \mid S_a \mid a$$

$$B \rightarrow c B_d \mid c S_d \mid c d$$

$$S \rightarrow S S_1 \mid B X_0 \mid S X_a \mid a$$

$$S_1 \rightarrow X_a S_2$$

$$S_2 \rightarrow S S_3$$

$$S_3 \rightarrow X_b X_c$$

$$B \rightarrow X_c B_1 \mid X_1 B_2 \mid X_c X_d$$

$$B_1 \rightarrow B X_4$$

$$B_2 \rightarrow S X_6$$

$$X_a \rightarrow a$$

$$X_b \rightarrow b$$

$$X_c \rightarrow c$$

$$X_d \rightarrow d$$



5  $S \rightarrow A^* A^* A^*$   
 $A \rightarrow S S^* A$

$S \rightarrow A^* S^* A^* A^* A^*$   
 $A \rightarrow S^* S^* A^* S^* A^* A^* A^*$

$A \rightarrow A^* A^* A^*$   
 $A' \rightarrow S^* S^* A^* S^* A^* A^*$

$S \rightarrow A^* S^* A^* S^* A^* A^* A^*$

$A \rightarrow A^* A^*$

$A \rightarrow S^* S^* A^* S^* S^* A^* S^* A^* S^* A^* A^* A^* A^*$   
 $A \rightarrow S^* S^* A^* S^* A^* A^*$

7 Yes. All cells can be described and are unique so they are countable.

b No. There are languages in  $\mathcal{M}_k$  that cannot be described so they cannot be given a value. This makes the set uncountable.

c No.  $\mathcal{M}_k \cdot \mathcal{D}$  so it is countable because empty set is countable.

8 Error 2  $D_1$  from front of string & then end of string.  
 If type is empty except return to front of string. Check  
 if there are equal number first  $D_1$ ,  $b$ , & second  $D_1$  by  
 marking off first unmarked of each until reach end of string.  
 When finished marking first set of  $D_1$ , check that rest of string has been marked.

$Q$	$Q_0$	$Q_1$	$Q_2$	$Q_3$	$Q_4$	$Q_5$	$Q_6$	$Q_7$	$Q_8$	$Q_9$	$Q_{10}$	$Q_{11}$	$Q_{12}$	$Q_{13}$	$Q_{14}$	$Q_{15}$	$Q_{16}$	$Q_{17}$	$Q_{18}$	$Q_{19}$	$Q_{20}$	$Q_{21}$	$Q_{22}$	$Q_{23}$	$Q_{24}$	$Q_{25}$	$Q_{26}$	$Q_{27}$	$Q_{28}$	$Q_{29}$	$Q_{30}$	$Q_{31}$	$Q_{32}$	$Q_{33}$	$Q_{34}$	$Q_{35}$	$Q_{36}$	$Q_{37}$	$Q_{38}$	$Q_{39}$	$Q_{40}$	$Q_{41}$	$Q_{42}$	$Q_{43}$	$Q_{44}$	$Q_{45}$	$Q_{46}$	$Q_{47}$	$Q_{48}$	$Q_{49}$	$Q_{50}$	$Q_{51}$	$Q_{52}$	$Q_{53}$	$Q_{54}$	$Q_{55}$	$Q_{56}$	$Q_{57}$	$Q_{58}$	$Q_{59}$	$Q_{60}$	$Q_{61}$	$Q_{62}$	$Q_{63}$	$Q_{64}$	$Q_{65}$	$Q_{66}$	$Q_{67}$	$Q_{68}$	$Q_{69}$	$Q_{70}$	$Q_{71}$	$Q_{72}$	$Q_{73}$	$Q_{74}$	$Q_{75}$	$Q_{76}$	$Q_{77}$	$Q_{78}$	$Q_{79}$	$Q_{80}$	$Q_{81}$	$Q_{82}$	$Q_{83}$	$Q_{84}$	$Q_{85}$	$Q_{86}$	$Q_{87}$	$Q_{88}$	$Q_{89}$	$Q_{90}$	$Q_{91}$	$Q_{92}$	$Q_{93}$	$Q_{94}$	$Q_{95}$	$Q_{96}$	$Q_{97}$	$Q_{98}$	$Q_{99}$	$Q_{100}$	$Q_{101}$	$Q_{102}$	$Q_{103}$	$Q_{104}$	$Q_{105}$	$Q_{106}$	$Q_{107}$	$Q_{108}$	$Q_{109}$	$Q_{110}$	$Q_{111}$	$Q_{112}$	$Q_{113}$	$Q_{114}$	$Q_{115}$	$Q_{116}$	$Q_{117}$	$Q_{118}$	$Q_{119}$	$Q_{120}$	$Q_{121}$	$Q_{122}$	$Q_{123}$	$Q_{124}$	$Q_{125}$	$Q_{126}$	$Q_{127}$	$Q_{128}$	$Q_{129}$	$Q_{130}$	$Q_{131}$	$Q_{132}$	$Q_{133}$	$Q_{134}$	$Q_{135}$	$Q_{136}$	$Q_{137}$	$Q_{138}$	$Q_{139}$	$Q_{140}$	$Q_{141}$	$Q_{142}$	$Q_{143}$	$Q_{144}$	$Q_{145}$	$Q_{146}$	$Q_{147}$	$Q_{148}$	$Q_{149}$	$Q_{150}$	$Q_{151}$	$Q_{152}$	$Q_{153}$	$Q_{154}$	$Q_{155}$	$Q_{156}$	$Q_{157}$	$Q_{158}$	$Q_{159}$	$Q_{160}$	$Q_{161}$	$Q_{162}$	$Q_{163}$	$Q_{164}$	$Q_{165}$	$Q_{166}$	$Q_{167}$	$Q_{168}$	$Q_{169}$	$Q_{170}$	$Q_{171}$	$Q_{172}$	$Q_{173}$	$Q_{174}$	$Q_{175}$	$Q_{176}$	$Q_{177}$	$Q_{178}$	$Q_{179}$	$Q_{180}$	$Q_{181}$	$Q_{182}$	$Q_{183}$	$Q_{184}$	$Q_{185}$	$Q_{186}$	$Q_{187}$	$Q_{188}$	$Q_{189}$	$Q_{190}$	$Q_{191}$	$Q_{192}$	$Q_{193}$	$Q_{194}$	$Q_{195}$	$Q_{196}$	$Q_{197}$	$Q_{198}$	$Q_{199}$	$Q_{200}$	$Q_{201}$	$Q_{202}$	$Q_{203}$	$Q_{204}$	$Q_{205}$	$Q_{206}$	$Q_{207}$	$Q_{208}$	$Q_{209}$	$Q_{210}$	$Q_{211}$	$Q_{212}$	$Q_{213}$	$Q_{214}$	$Q_{215}$	$Q_{216}$	$Q_{217}$	$Q_{218}$	$Q_{219}$	$Q_{220}$	$Q_{221}$	$Q_{222}$	$Q_{223}$	$Q_{224}$	$Q_{225}$	$Q_{226}$	$Q_{227}$	$Q_{228}$	$Q_{229}$	$Q_{230}$	$Q_{231}$	$Q_{232}$	$Q_{233}$	$Q_{234}$	$Q_{235}$	$Q_{236}$	$Q_{237}$	$Q_{238}$	$Q_{239}$	$Q_{240}$	$Q_{241}$	$Q_{242}$	$Q_{243}$	$Q_{244}$	$Q_{245}$	$Q_{246}$	$Q_{247}$	$Q_{248}$	$Q_{249}$	$Q_{250}$	$Q_{251}$	$Q_{252}$	$Q_{253}$	$Q_{254}$	$Q_{255}$	$Q_{256}$	$Q_{257}$	$Q_{258}$	$Q_{259}$	$Q_{260}$	$Q_{261}$	$Q_{262}$	$Q_{263}$	$Q_{264}$	$Q_{265}$	$Q_{266}$	$Q_{267}$	$Q_{268}$	$Q_{269}$	$Q_{270}$	$Q_{271}$	$Q_{272}$	$Q_{273}$	$Q_{274}$	$Q_{275}$	$Q_{276}$	$Q_{277}$	$Q_{278}$	$Q_{279}$	$Q_{280}$	$Q_{281}$	$Q_{282}$	$Q_{283}$	$Q_{284}$	$Q_{285}$	$Q_{286}$	$Q_{287}$	$Q_{288}$	$Q_{289}$	$Q_{290}$	$Q_{291}$	$Q_{292}$	$Q_{293}$	$Q_{294}$	$Q_{295}$	$Q_{296}$	$Q_{297}$	$Q_{298}$	$Q_{299}$	$Q_{300}$	$Q_{301}$	$Q_{302}$	$Q_{303}$	$Q_{304}$	$Q_{305}$	$Q_{306}$	$Q_{307}$	$Q_{308}$	$Q_{309}$	$Q_{310}$	$Q_{311}$	$Q_{312}$	$Q_{313}$	$Q_{314}$	$Q_{315}$	$Q_{316}$	$Q_{317}$	$Q_{318}$	$Q_{319}$	$Q_{320}$	$Q_{321}$	$Q_{322}$	$Q_{323}$	$Q_{324}$	$Q_{325}$	$Q_{326}$	$Q_{327}$	$Q_{328}$	$Q_{329}$	$Q_{330}$	$Q_{331}$	$Q_{332}$	$Q_{333}$	$Q_{334}$	$Q_{335}$	$Q_{336}$	$Q_{337}$	$Q_{338}$	$Q_{339}$	$Q_{340}$	$Q_{341}$	$Q_{342}$	$Q_{343}$	$Q_{344}$	$Q_{345}$	$Q_{346}$	$Q_{347}$	$Q_{348}$	$Q_{349}$	$Q_{350}$	$Q_{351}$	$Q_{352}$	$Q_{353}$	$Q_{354}$	$Q_{355}$	$Q_{356}$	$Q_{357}$	$Q_{358}$	$Q_{359}$	$Q_{360}$	$Q_{361}$	$Q_{362}$	$Q_{363}$	$Q_{364}$	$Q_{365}$	$Q_{366}$	$Q_{367}$	$Q_{368}$	$Q_{369}$	$Q_{370}$	$Q_{371}$	$Q_{372}$	$Q_{373}$	$Q_{374}$	$Q_{375}$	$Q_{376}$	$Q_{377}$	$Q_{378}$	$Q_{379}$	$Q_{380}$	$Q_{381}$	$Q_{382}$	$Q_{383}$	$Q_{384}$	$Q_{385}$	$Q_{386}$	$Q_{387}$	$Q_{388}$	$Q_{389}$	$Q_{390}$	$Q_{391}$	$Q_{392}$	$Q_{393}$	$Q_{394}$	$Q_{395}$	$Q_{396}$	$Q_{397}$	$Q_{398}$	$Q_{399}$	$Q_{400}$	$Q_{401}$	$Q_{402}$	$Q_{403}$	$Q_{404}$	$Q_{405}$	$Q_{406}$	$Q_{407}$	$Q_{408}$	$Q_{409}$	$Q_{410}$	$Q_{411}$	$Q_{412}$	$Q_{413}$	$Q_{414}$	$Q_{415}$	$Q_{416}$	$Q_{417}$	$Q_{418}$	$Q_{419}$	$Q_{420}$	$Q_{421}$	$Q_{422}$	$Q_{423}$	$Q_{424}$	$Q_{425}$	$Q_{426}$	$Q_{427}$	$Q_{428}$	$Q_{429}$	$Q_{430}$	$Q_{431}$	$Q_{432}$	$Q_{433}$	$Q_{434}$	$Q_{435}$	$Q_{436}$	$Q_{437}$	$Q_{438}$	$Q_{439}$	$Q_{440}$	$Q_{441}$	$Q_{442}$	$Q_{443}$	$Q_{444}$	$Q_{445}$	$Q_{446}$	$Q_{447}$	$Q_{448}$	$Q_{449}$	$Q_{450}$	$Q_{451}$	$Q_{452}$	$Q_{453}$	$Q_{454}$	$Q_{455}$	$Q_{456}$	$Q_{457}$	$Q_{458}$	$Q_{459}$	$Q_{460}$	$Q_{461}$	$Q_{462}$	$Q_{463}$	$Q_{464}$	$Q_{465}$	$Q_{466}$	$Q_{467}$	$Q_{468}$	$Q_{469}$	$Q_{470}$	$Q_{471}$	$Q_{472}$	$Q_{473}$	$Q_{474}$	$Q_{475}$	$Q_{476}$	$Q_{477}$	$Q_{478}$	$Q_{479}$	$Q_{480}$	$Q_{481}$	$Q_{482}$	$Q_{483}$	$Q_{484}$	$Q_{485}$	$Q_{486}$	$Q_{487}$	$Q_{488}$	$Q_{489}$	$Q_{490}$	$Q_{491}$	$Q_{492}$	$Q_{493}$	$Q_{494}$	$Q_{495}$	$Q_{496}$	$Q_{497}$	$Q_{498}$	$Q_{499}$	$Q_{500}$	$Q_{501}$	$Q_{502}$	$Q_{503}$	$Q_{504}$	$Q_{505}$	$Q_{506}$	$Q_{507}$	$Q_{508}$	$Q_{509}$	$Q_{510}$	$Q_{511}$	$Q_{512}$	$Q_{513}$	$Q_{514}$	$Q_{515}$	$Q_{516}$	$Q_{517}$	$Q_{518}$	$Q_{519}$	$Q_{520}$	$Q_{521}$	$Q_{522}$	$Q_{523}$	$Q_{524}$	$Q_{525}$	$Q_{526}$	$Q_{527}$	$Q_{528}$	$Q_{529}$	$Q_{530}$	$Q_{531}$	$Q_{532}$	$Q_{533}$	$Q_{534}$	$Q_{535}$	$Q_{536}$	$Q_{537}$	$Q_{538}$	$Q_{539}$	$Q_{540}$	$Q_{541}$	$Q_{542}$	$Q_{543}$	$Q_{544}$	$Q_{545}$	$Q_{546}$	$Q_{547}$	$Q_{548}$	$Q_{549}$	$Q_{550}$	$Q_{551}$	$Q_{552}$	$Q_{553}$	$Q_{554}$	$Q_{555}$	$Q_{556}$	$Q_{557}$	$Q_{558}$	$Q_{559}$	$Q_{560}$	$Q_{561}$	$Q_{562}$	$Q_{563}$	$Q_{564}$	$Q_{565}$	$Q_{566}$	$Q_{567}$	$Q_{568}$	$Q_{569}$	$Q_{570}$	$Q_{571}$	$Q_{572}$	$Q_{573}$	$Q_{574}$	$Q_{575}$	$Q_{576}$	$Q_{577}$	$Q_{578}$	$Q_{579}$	$Q_{580}$	$Q_{581}$	$Q_{582}$	$Q_{583}$	$Q_{584}$	$Q_{585}$	$Q_{586}$	$Q_{587}$	$Q_{588}$	$Q_{589}$	$Q_{590}$	$Q_{591}$	$Q_{592}$	$Q_{593}$	$Q_{594}$	$Q_{595}$	$Q_{596}$	$Q_{597}$	$Q_{598}$	$Q_{599}$	$Q_{600}$	$Q_{601}$	$Q_{602}$	$Q_{603}$	$Q_{604}$	$Q_{605}$	$Q_{606}$	$Q_{607}$	$Q_{608}$	$Q_{609}$	$Q_{610}$	$Q_{611}$	$Q_{612}$	$Q_{613}$	$Q_{614}$	$Q_{615}$	$Q_{616}$	$Q_{617}$	$Q_{618}$	$Q_{619}$	$Q_{620}$	$Q_{621}$	$Q_{622}$	$Q_{623}$	$Q_{624}$	$Q_{625}$	$Q_{626}$	$Q_{627}$	$Q_{628}$	$Q_{629}$	$Q_{630}$	$Q_{631}$	$Q_{632}$	$Q_{633}$	$Q_{634}$	$Q_{635}$	$Q_{636}$	$Q_{637}$	$Q_{638}$	$Q_{639}$	$Q_{640}$	$Q_{641}$	$Q_{642}$	$Q_{643}$	$Q_{644}$	$Q_{645}$	$Q_{646}$	$Q_{647}$	$Q_{648}$	$Q_{649}$	$Q_{650}$	$Q_{651}$	$Q_{652}$	$Q_{653}$	$Q_{654}$	$Q_{655}$	$Q_{656}$	$Q_{657}$	$Q_{658}$	$Q_{659}$	$Q_{660}$	$Q_{661}$	$Q_{662}$	$Q_{663}$	$Q_{664}$	$Q_{665}$	$Q_{666}$	$Q_{667}$	$Q_{668}$	$Q_{669}$	$Q_{670}$	$Q_{671}$	$Q_{672}$	$Q_{673}$	$Q_{674}$	$Q_{675}$	$Q_{676}$	$Q_{677}$	$Q_{678}$	$Q_{679}$	$Q_{680}$	$Q_{681}$	$Q_{682}$	$Q_{683}$	$Q_{684}$	$Q_{685}$	$Q_{686}$	$Q_{687}$	$Q_{688}$	$Q_{689}$	$Q_{690}$	$Q_{691}$	$Q_{692}$	$Q_{693}$	$Q_{694}$	$Q_{695}$	$Q_{696}$	$Q_{697}$	$Q_{698}$	$Q_{699}$	$Q_{700}$	$Q_{701}$	$Q_{702}$	$Q_{703}$	$Q_{704}$	$Q_{705}$	$Q_{706}$	$Q_{707}$	$Q_{708}$	$Q_{709}$	$Q_{710}$	$Q_{711}$	$Q_{712}$	$Q_{713}$	$Q_{714}$	$Q_{715}$	$Q_{716}$	$Q_{717}$	$Q_{718}$	$Q_{719}$	$Q_{720}$	$Q_{721}$	$Q_{722}$	$Q_{723}$	$Q_{724}$	$Q_{725}$	$Q_{726}$	$Q_{727}$	$Q_{728}$	$Q_{729}$	$Q_{730}$	$Q_{731}$	$Q_{732}$	$Q_{733}$	$Q_{734}$	$Q_{735}$	$Q_{736}$	$Q_{737}$	$Q_{738}$	$Q_{739}$	$Q_{740}$	$Q_{741}$	$Q_{742}$	$Q_{743}$	$Q_{744}$	$Q_{745}$	$Q_{746}$	$Q_{747}$	$Q_{748}$	$Q_{749}$	$Q_{750}$	$Q_{751}$	$Q_{752}$	$Q_{753}$	$Q_{754}$	$Q_{755}$	$Q_{756}$	$Q_{757}$	$Q_{758}$	$Q_{759}$	$Q_{760}$	$Q_{761}$	$Q_{762}$	$Q_{763}$	$Q_{764}$	$Q_{765}$	$Q_{766}$	$Q_{767}$	$Q_{768}$	$Q_{769}$	$Q_{770}$	$Q_{771}$	$Q_{772}$	$Q_{773}$	$Q_{774}$	$Q_{775}$	$Q_{776}$	$Q_{777}$	$Q_{778}$	$Q_{779}$	$Q_{780}$	$Q_{781}$	$Q_{782}$	$Q_{783}$	$Q_{784}$	$Q_{785}$	$Q_{786}$	$Q_{787}$	$Q_{788}$	$Q_{789}$	$Q_{790}$	$Q_{791}$	$Q_{792}$	$Q_{793}$	$Q_{794}$	$Q_{795}$	$Q_{796}$	$Q_{797}$	$Q_{798}$	$Q_{799}$	$Q_{800}$	$Q_{801}$	$Q_{802}$	$Q_{803}$	$Q_{804}$	$Q_{805}$	$Q_{806}$	$Q_{807}$	$Q_{808}$	$Q_{809}$	$Q_{810}$	$Q_{811}$	$Q_{812}$	$Q_{813}$	$Q_{814}$	$Q_{815}$	$Q_{816}$	$Q_{817}$	$Q_{818}$	$Q_{819}$	$Q_{820}$	$Q_{821}$	$Q_{822}$	$Q_{823}$	$Q_{824}$	$Q_{825}$	$Q_{826}$	$Q_{827}$	$Q_{828}$	$Q_{829}$	$Q_{830}$	$Q_{831}$	$Q_{832}$	$Q_{833}$	$Q_{834}$	$Q_{835}$	$Q_{836}$	$Q_{837}$	$Q_{838}$	$Q_{839}$	$Q_{840}$	$Q_{841}$	$Q_{842}$	$Q_{843}$	$Q_{844}$	$Q_{845}$	$Q_{846}$	$Q_{847}$	$Q_{848}$	$Q_{849}$	$Q_{850}$	$Q_{851}$	$Q_{852}$	$Q_{853}$	$Q_{854}$	$Q_{855}$	$Q_{856}$	$Q_{857}$	$Q_{858}$	$Q_{859}$	$Q_{860}$	$Q_{861}$	$Q_{862}$	$Q_{863}$	$Q_{864}$	$Q_{865}$	$Q_{866}$	$Q_{867}$	$Q_{868}$	$Q_{869}$	$Q_{870}$	$Q_{871}$	$Q_{872}$	$Q_{873}$	$Q_{874}$	$Q_{875}$	$Q_{876}$	$Q_{877}$	$Q_{878}$	$Q_{879}$	$Q_{880}$	$Q_{881}$	$Q_{882}$	$Q_{883}$	$Q_{884}$	$Q_{885}$	$Q_{886}$	$Q_{887}$	$Q_{888}$	$Q_{889}$	$Q_{890}$	$Q_{$
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9.  $L_1, L_2$  is recursive because recursive languages are closed under complement & set difference. A TM is deciding if a word is in a recursive language is feasible.

10.  $L_1, L_2$  is not c.e. because c.e. languages that are not recursive are not closed under complement or set difference. The problem is undecidable.

2. undecidable.  $L_1 \neq \emptyset$  if  $L_1 = L_2$ . To prove that two languages are different a word must be found that is in one but not the other. This is c.e.

11.  $L_1, L_2$  is not c.e. Because there is no way to prove that the language contains a word, the problem is undecidable.

3.  $L_1, L_2$  is recursive. Recursive languages are closed under intersection.

A TM for the language would be recursive.

12.  $L_1, L_2$  is c.e. because i.e. languages are closed under intersection.

A TM for this language would be c.e.

4.  $L_1, L_2 \neq \emptyset$  Same logic as 7. c.e.

$L_1 \cap L_2 \neq \emptyset$

$L_1 \cap L_2 \neq \emptyset$

$L_1 \cap L_2$

13. Same logic as 7. not c.e.