(15 points)

(M) Orwellspeak (1/5)
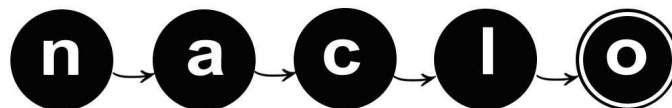
Part 1. Opposites Attract

Here is a fragment of an English grammar. If you speak according to this grammar, you will utter sentences like `happy people love charming bad people.`

1.	**Sentence** →	**NounPhrase + Verb + NounPhrase**
2.	**NounPhrase** →	**Noun**
3.	**NounPhrase** →	**Adjective + NounPhrase**

4.	**Noun** →	`people`
5.	**Verb** →	`love`
6.	**Adjective** →	`good`
7.	**Adjective** →	`charming`
8.	**Adjective** →	`happy`
9.	**Adjective** →	`bad`
10.	**Adjective** →	`obnoxious`
11.	**Adjective** →	`unhappy`

What do the above grammar rules mean? For example,

- Rule 1 says that to utter a **Sentence**, one must utter a **NounPhrase**, then a **Verb**, then a **NounPhrase**
- Rules 2-3 offer two choices for uttering a **NounPhrase**: one may either utter a **Noun**, or utter an **Adjective** followed by another **NounPhrase**.
- Rules 6-11 offer several choices of **Adjective**.

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(M) Orwellspeak (2/5)

Now, keep in mind that **opposites attract**. So it is true that
- `good people love bad people`
- `good happy people love obnoxious people`
- `happy charming people love unhappy obnoxious bad unhappy`
      `unhappy people`

and also vice-versa,
- `bad people love good people`
- `obnoxious people love good happy people`
- `unhappy obnoxious bad unhappy unhappy people love happy`
      `charming people`

But it is false that
- `good people love good people`
- `obnoxious people love bad unhappy people`
- `people love good people`

M1. Following the example of the totalitarian government in George Orwell's famous book *1984*, we would like you to revise the grammar of English so that it does not permit false **Sentences**.[1] The above grammar permits many **Sentences**. Your revised grammar should permit only a subset of these, using the same notation. It should systematically enforce the principle that opposites (and only opposites) attract. For example, it should be possible to utter the true example **Sentences** above but not the false ones. It should also be impossible to discuss `charming bad people` or `unhappy good people`. (Such people pose intolerable problems for our moral philosophy, and their situations will be corrected forthwith.)

Please show your revisions directly on the grammar on the previous page, using the same notation, by adding new rules and by crossing out or otherwise modifying some of the old rules.

———————————

[1] "It was intended that when Newspeak had been adopted once and for all and Oldspeak forgotten, a heretical thought—that is, a thought diverging from the principles of [the Party] - should be literally unthinkable, at least so far as thought is dependent on words. Its vocabulary was so constructed as to give exact and often very subtle expression to every meaning that a Party member could properly wish to express, while excluding all other meaning . . . " - from "The Principles of Newspeak", an appendix to *1984* by G. Orwell, 1948.

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(M) Orwellspeak (3/5)

Part 2. Censorship

Consider again the setting of the previous problem ("Opposites Attract"). You can do this problem even if you did not solve the previous problem.

In an orderly society, only true, well-formed sentences should be uttered. Thus, our censors should detect illegal utterances like

- `good people love happy people` (which is false since only opposites attract)
- `bad bad bad` (which is nonsense and possibly a subversive code)
- `good charming people love` (which is not a complete sentence)

To be precise, if an utterance is a possible **Sentence** under the revised grammar that you were asked to write in the previous problem, then it is legal. Otherwise it is illegal and must be censored.

A vendor of censorship software has proposed a faster solution that does not use a grammar. Their device censors an utterance if and only if it contains at least one **bad phrase**. Each bad phrase in the device's memory is a sequence of **up to 4** adjacent words.

An input utterance would be presented in the form

```
START good people love obnoxious happy END
```

Input utterances may be of any length. You may assume that they begin with START and end with END, and that in between, they use only words from the 8-word vocabulary

`{people, love, good, charming, happy, bad, obnoxious, unhappy}`.

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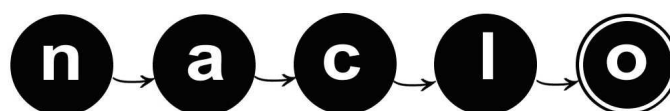
(M) Orwellspeak (4/5)

M2. The vendor's device has been carefully constructed to censor as many illegal utterances as possible while not censoring any legal ones. What is the shortest possible list of bad phrases that will do this? Write out a summary of the phrases on the list, and be sure to give the total number of phrases. For example, the list might include the 2-word bad phrase `people charming`, since this can never occur in a legal sentence. To indicate that there are 6 bad phrases of this general form, your summary list might include a line

<div align="center">

`people` **Adjective** (6)

</div>

or if you prefer,

<div align="center">

Noun Adjective (6)

</div>

(Hint: The vocabulary consists of **1 Noun**, **1 Verb**, 3 positive **Adjective**s, and 3 negative **Adjective**s. A bad phrase may contain any of these words, and may also contain START and/or END. Remember that a bad phrase may consist of UP TO 4 adjacent words)

(M) Orwellspeak (5/5)

EXTRA SPACE FOR PART **M2.**

M3. Does the resulting device ever fail to censor an illegal utterance? If so, give an example.

M4. Suppose the government tightens its grip, and requires that the vendor modify its machine to censor ALL illegal utterances (even if this means censoring some legal ones as well). What is the shortest possible list of bad phrases that meets this new requirement?