Soundness and Completeness

Soundness

1. Soundness: A sound analysis means we can trust the correctness of its output. If it says a program is correct, the program is definitely correct. However, the analysis may improperly say some programs are not correct.

Trivially Sound Quiz

1. Trivially sound analysis rejects all inputs

```
bool trivialSoundAnalysis() {
    return false;
}
```

Soundness Continued

1. Trivially sound analysis
   - Returns false for all inputs
2. Example: Verifying a car drive by wire/brake by wire system
   - Electrical connections instead of mechanical connections
     - Software controls the electrical connections
   - Need absolute confidence that the software controlling the acceleration and braking of your car is correct

Completeness

1. Completeness: A complete analysis means we can trust that what it excludes from its analysis is incorrect. If it says that a program is not correct, then the program is definitely not correct. However, the analysis may improperly say some incorrect programs are correct.

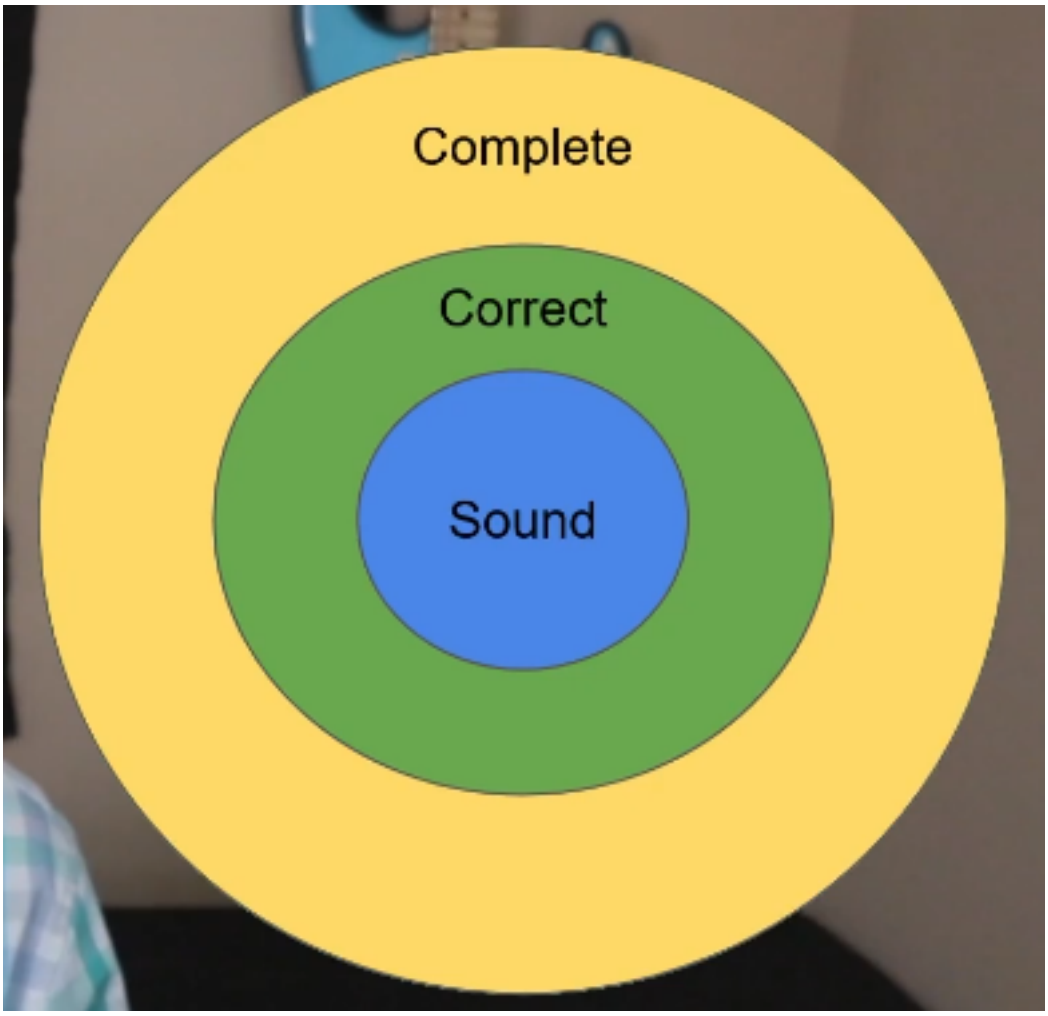
Trivially Complete Quiz

1. Trivially complete analysis accepts all inputs

```
bool trivialCompleteAnalysis() {
    return true;
}
```

Completeness and Perspective

1. Trivially complete analysis
   - Returns true for all inputs
2. Example: Analyzing if a fire alarm should trigger
3. Sound $<$ Correct $<$ Complete
   - All sound programs are correct
   - All correct programs are complete
4. False positive: We say a condition is true when it's actually false
5. False negative: We say a condition is false when it's actually true



Soundness, Completeness, Correctness

6. Error-containing vs Correct Programs
   - False positive/negative depends on the frame of reference

Perspective Quiz

1. Order the items in the circle for an error-containing program instead of a correct program
   - Sound
   - Error-containing
   - Complete

Example Problems

1. Vibhuti is participating in a bug bounty program at her employer. For every bug she finds using software analysis in production code, she gets $500. However, she is banned from getting any rewards if she submits a bug and it is found to be invalid. What kind of analysis should she use?
   - Desire: Certainty
   - Frame of reference: Correct software
   - Result: Sound analysis
2. Julio works for a paper manufacturer. The manufacturer has been having an issue with the safety control programs causing the plant to shut down in error at least every dat. Since each time the plant

stops the company loses thousands of dollars, Julio has been asked to use an analysis to prevent the plant from stopping when there is no problem.

- Desire: Certainty
- Frame of reference: Error-containing software
- Complete analysis

Where Do We Go From Here?

1. Soundness and completeness will come up again
2. Be sure to consider the perspective of the analysis, what is being checked, when using false positive or false negative!