Answer Sheet

Section A: Short Answer [80 points]

1. James Webb Space Telescope
2. True
3. False
4. 36.92°
5. 1.309
6. red, green, blue, and white
7. cyan, yellow, magenta, and black
8. 7.431°
9. 48.75°
10. 16.34 m^2
11. Achromatic doublet
12. 2.209×10^{-19} J
13. 45°
14. No
15. 1.15×10^8 m/s
16. 1:2:1
17. False
18. Unpolarized
19. 33.33 nanometers
20. 3.61×10^{-19} Joules
21. +36 cm
22. −8 cm
23. True
24. 20 cm
25. 15 cm
26. $\sqrt{2}$
27. -4.60 cm
28. 30 cm
29. Huygen's Principle
30. White
31. 0.014 arcseconds
32. 75.98°
33. 110 Hz
34. 60.53°
35. 299,792,458 m/s
36. 2
37. 33.37°
38. 7×10^{-4} meters
39. Dark
40. Hydrogen

Section B: Free Response Questions [40 points]
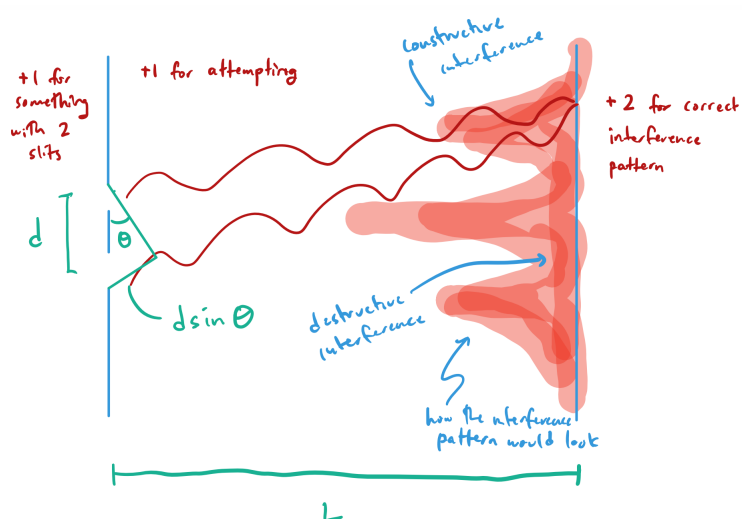
1. (a) (4 points) The plot should look as such:
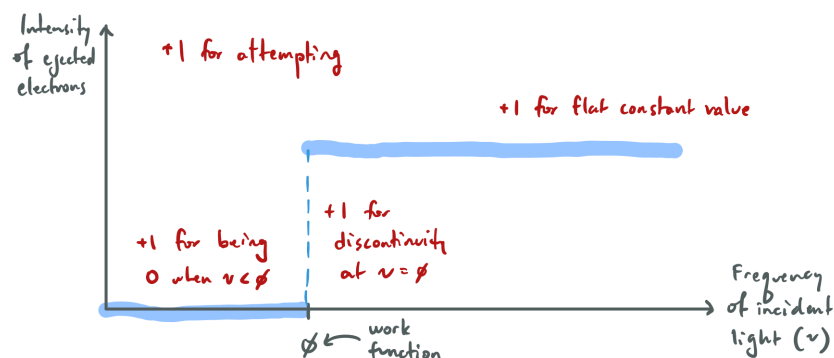
(b) (4 points) The plot should look as such:
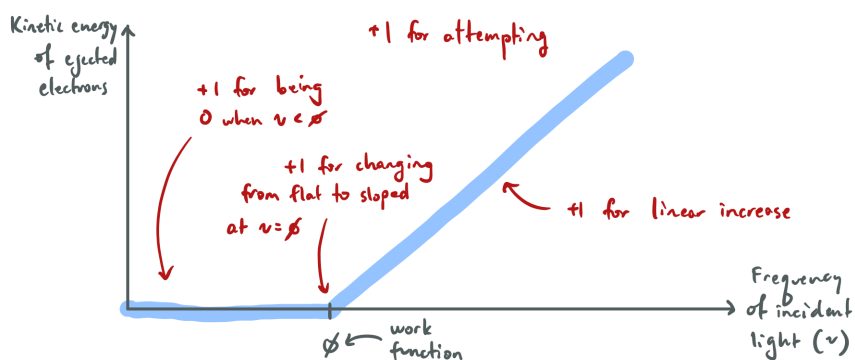
(c) (4 points) Things we often think of as waves, like light, have particle-like properties.

(d) (4 points) The plot should look as such:

(e) (4 points) Things we often think of as particles, like electrons or nuclei, have wave-like properties.

2. (a) (2 points) Accept answers between 349 and 350 m/s

   (b) (4 points) At the closed end, there is no space for the molecules to physically move, resulting in the displacement node [1]. At exactly the open end, the pressure should theoretically be the same as the ambient air pressure, resulting in a pressure node [1]. In order to keep the pressure the same, the molecules all have to move (to prevent them from "bunching up" and causing areas of high/low pressure [2].

   (c) (4 points) Accept only exactly 1 cm

   (d) (4 points) Taken from Physics Stack Exchange: If there were to be no end correction, then the standing wave pattern inside the tube would have to end in a node coinciding with the plane of the mouth of the tube. The spherical pattern would then have to start abruptly at that plane as well, as suggested by the figure. But the point of the figure is that it's clearly unphysical. This abrupt boundary between the plane-wave and spherical-wave behavior, which is obvious on the figure, clearly can't be a solution to the wave equation, because it has discontinuities in it. There has to be a smooth transition from the standing wave inside the tube to the spherical radiation pattern outside the tube. This transition region is the extra length that is accounted for in the end correction [3].

   This effect would be more pronounced in pipes with larger radii [1].

3. (a) (2 points) Accept answers between 10,000 and 12,000 days.

   (b) (2 points) Jupiter [1]. Accept answers between 2.2×10^{-9} and 2.9×10^{-9} Hz [1].

   (c) (2 points) $2/\sqrt{3}$