Answer Key

1. D	8. C	15. C	22. D	29. B
2. D	9. A	16. C	23. D	30. C
3. C	10. B	17. A	24. B	31. B
4. B	11. B	18. C	25. A	32. C
5. C	12. C	19. D	26. A	
6. A	13. C	20. B	27. B	
7. D	14. C	21. C	28. C	

33. (a) 3C 273
    (b) i. 4
        ii. 11.8
        iii. 42.9 kpc
        iv. It decays (like an exponential or maybe a power law).

34. (a) Dark matter is an unidentified source of gravity, thought to be a very weakly-interacting type of particle. Dark energy is the energy of space that drives the expansion of the universe. In a sense, they work against each other.
    (b) About 25% dark matter, 70% dark energy (add up to 95%)
    (c) Since rotation curves level out instead of decaying with distance, there must be an unexplained source of gravity. This gravity is thought to originate from dark matter spread throughout the galaxy.
    (d) In modern usage, they are effectively synonymous. The cosmological constant was Einstein's invention, which he used for a different purpose (static universe model), and was revived upon the discovery of dark energy.

35. (a) $d \approx \frac{1}{\theta} = 90$ parsecs (small angle approximation)
    (b) $0.10/5 = 0.02$ arcseconds/year
    (c) $.02 * 90 * \frac{1 \text{ rad}}{206265 \text{ arcsec}} * \frac{3.08e13 \text{ km}}{\text{pc}} * \frac{1 \text{ yr}}{3.15e7 \text{ s}} = 8.5$ km/s (small angle approximation)
    (d) $\frac{\Delta\lambda}{\lambda_0} * c = \frac{0.02}{656.28} * 2.99 \times 10^5 = 9.1$ km/s
    (e) $\sqrt{8.5^2 + 9.1^2} = 12.5$ km/s
    (f) $\frac{v}{H_0} = \frac{9.1}{70} = 0.13 \text{ Mpc} = 130,600 \text{ pc}$
    (g) When calculating the distance using Hubble's Law, the astronomer is assuming that the object is quite far away and the majority of its recessional velocity is coming from the expansion of the universe. However, this star is undoubtedly within our own galaxy (it is very hard to measure the properties of distant stars accurately and parallax is very accurate for relatively short distances). Its motion through the galaxy and gravitational interactions with nearby objects will be much more significant than the recessional velocity caused by the expansion of the universe. As a result, the distance obtained using parallax measurements will be much more accurate than the one found by applying Hubble's Law.