2022 PhysicsBowl Answers and Solutions

1. A $KE_1=KE_2$; $\frac{1}{2} m_1 v_1^2=\frac{1}{2} m_2 v_2^2$; $v_1=6.9$ m/s

2. B See: https://www.space.com/20790-eugene-cernan-astronaut-biography.html

3. C $v = \frac{2\pi r}{t}; a = \frac{v^2}{r}$

4. B $mv_{before} = (m+M)v_{after}; v_{after} = \frac{mv_{before}}{(m+M)}$;

$KE = \frac{1}{2}(m+M){v^2}_{after} = \frac{1}{2}\frac{m^2 {v^2}_{before}}{(m+M)}$; W=$\mu(m+M)g\Delta x$

5. B $v = v_0 + at$; $\sum \vec{F} = m\vec{a}$

6. D The sum will not equal one of the magnitudes.

7. E Violet: 380-430 nm, Blue: 430-500 nm, Cyan: 500-520 nm, Green: 520-565 nm, Yellow: 565-580 nm, Orange: 580-625 nm, Red: 625-740 nm

8. C PV=nRT

9. B KE converted to gravitational potential energy, thermal energy, and work

10. E $\omega = 2\pi f; t = \frac{1}{f} = 2\pi\sqrt{\frac{m}{k}};\ \omega = \sqrt{\frac{k}{m}}; F_{max} = m\omega^2 A$

11. E See: https://en.wikipedia.org/wiki/James_E._Webb

12. C $\frac{1.5 \text{ x } 10^9\ m}{3.0 \text{ x } 10^8\ m/s} = 5\ s$

13. A V=(l)(A); $A=\pi r^2$

14. D $\tan\theta = \frac{opposite}{adjacent}$

15. D $T_1 = 2\pi\sqrt{\frac{60}{g}}; T_2 = 2\pi\sqrt{\frac{63}{g}}$; $t=(n+1)T_1=nT_2$

16. C $R = \frac{\rho l}{A}; \frac{\Delta R}{R} = 2\frac{\Delta l}{l}$

17. E In the absence of friction, all gravitational potential energy will be converted to kinetic energy at the bottom of the plane.

18. C $\Delta x = v_0 t + \frac{1}{2}at^2$; t=2

19. B $F_{air} = \rho A v; F_g = mg; \rho A v = mg$

20. D $F_f = \mu mg;\ F_g = mg;\ \mu mg = mg$

21. C $T_2 = \frac{(m_1+m_2)F}{(m_1+m_2+m_3)}$

22. E $a_c = a_T = 10\ \frac{cm}{s^2};\ a_T = \omega^2 r;\ \omega = \omega_0 + \alpha t$

23. B $F_g = G\frac{m_1 m_2}{r^2}\ ;\ F_e = k\frac{q_1 q_2}{r^2}$

24. C $T = \sum F = ma + mg$

25. B With a one-wavelength path-length difference, crests will meet crests and troughs will meet troughs.

26. E Only choice with correct values

27. E $n = \frac{F}{mv}$

28. B $W_s = \frac{1}{2}kx^2;\ W_f = \frac{1}{2}mv^2 - W_s;\ W_f = \mu mg\Delta x$

29. B $P = Fv$

30. B $t = \frac{1}{60}s$ for each of the five displacement intervals.

31. B $t_1 = \sqrt{\frac{2h}{g}} = 0.7\ s;\ t_2 = 0.35\ s;\ \Delta x = \frac{1}{2}g{t_2}^2$

32. E $L = I\omega = \frac{2}{5}MR^2\frac{2\pi}{T}$

33. D $dB = 10\log(\frac{I}{I_0});\ I_0 = 10^{-12}\ \frac{W}{m^2}$

34. C $\sum F = F_e + F_g = qE + mg$

35. E $\frac{1}{f} = \frac{1}{d_0} + \frac{1}{d_i}$

36. A There is no dispersion in a glass block with parallel sides.

37. A $\Delta x_{rel} = \Delta x - \frac{1}{2}at^2 = 6\ m;\ v_{rel} = 20\ \frac{m}{s} - 16\ \frac{m}{s} = 4\ \frac{m}{s};\ a_{rel} = a_{car} - a_{truck};$

$$a_{car} = a_{truck} + \frac{v_{rel}^2}{2\Delta x_{rel}}$$

38. A With no resistance, ΔV will be the same across both components.

39. D $\vec{R} = \sqrt{p^2 + \left(\frac{4p}{3}\right)^2};\ \tan\theta = \frac{\frac{4p}{3}}{p} = 53^o;\ 180^o - 53^o = 127^o$

40. D $I_1\omega_1 = (0.8)I_2\omega_2$

41. C $\frac{P_1V_1}{T_1} = \frac{P_2V_2}{T_2}$

42. B $R_p = 2\ \Omega;\ R_{total} = 5\ \Omega; \mathrm{V} = \mathrm{IR}; \mathrm{I} = 24\ \mathrm{A}$

43. B $n_1 sin\Theta_1 = n_2 sin\Theta_2$

44. C $N(t) = N_0(\frac{1}{2})^{\frac{t}{t_{1/2}}}$

45. B $qE = qvB$

46. B The electric fields are pointed in opposite directions (45º and 225º from the x-axis) and therefore cancel each other out. Since each arc is a collection of point charges located the same distance from the origin, then: $V = \frac{kQ}{R}$. Both arcs create positive potentials, so $V = 2(\frac{kQ}{R})$.

47. A $F = F_f - F_g = \mu mgcos\theta - mgsin\theta$

48. D Combination Z, with three resistors in parallel, offers the least amount of resistance. Combination X, with two resistors in parallel and one in series, offers the most resistance.

49. C There are three main factors to consider here. The gravitational constant, *G*, the mass of the sun, *M*, and the distance between the sun and the earth, *R*. The units of *G* are $\frac{m^3}{(kg)s^2}$, the units of *M* are *kg*, the units of *R* are *m*, and we want to solve for time in seconds. Using dimensional analysis to solve for seconds, we get $Time = \sqrt{\frac{R^3}{GM}} = 5.1 \ x \ 10^6 \ seconds = 59 \ days$. Using calculus, one arrives at 64.5 days.

50. C $PV = nRT$; At the end of Stage 1: P=5.05 x 10^4 Pa, V=2 m^3, and T=273.15 K. At The end of Stage 2, P=1.01 x 10^5 Pa, V=2 m^3, and T=546.3 K. n=44.3 mol through the entire problem. Work done in Stage 3: $W_3=P_3(V_1-V_3)$.