2025 PhysicsBowl Answers and Solutions

1. C $Relative\ speed = 2.5\ \frac{m}{s} - 1.0\ \frac{m}{s} = 1.5\ \frac{m}{s}; t = \frac{x}{v} = \frac{50\ m}{1.5\ \frac{m}{s}} = 33.33\ s$

2. C The force of gravity acts equally on both balls, causing them to accelerate toward the floor at the same rate, regardless of their initial horizontal velocities. Because they were initially "aimed" at each other, they will collide.

3. D From the graph, the initial velocity is 3 $\frac{m}{s}$ and slope of the line (acceleration) is -2 $\frac{m}{s^2}$.

4. B http://airandspace.si.edu/explore/stories/apollo-missions/apollo-8

5. B Per Newton's 1st Law, the pendulum bob tends to remain at rest relative to the ground while the train is accelerating to the left.

6. A Work and torque are both measured in N·m

7. D $v = \frac{\Delta x}{\Delta t} = 5.0\ \frac{m}{s}; \frac{\Delta d}{d} = \frac{0.1\ m}{5.0\ m} = 0.02;\ \frac{\Delta t}{t} = \frac{0.02\ s}{1.00\ s} = 0.02$

$\frac{\Delta v}{v} = \sqrt{(0.02)^2 + (0.02)^2} = 0.0283; \Delta v = v * \frac{\Delta v}{v} = 5.0\ \frac{m}{s} * 0.0283 = 0.1415\ \frac{m}{s}$

8. C Swimming either upstream or downstream will change the swimmer's speed.

9. A $F\Delta t = m\Delta v; m\Delta v\ is\ constant\ in\ this\ situation.$

10. C $F\Delta t = m\Delta v$

11. C $h = l \sin\theta$=2.5 m; $KE_i + PE_i = KE_f + PE_f; 0 + mgh = \frac{1}{2}mv^2 + \frac{1}{2}I\omega^2 + 0;$

$mgh = \frac{3}{4}mv^2; v = 5.7\ \frac{m}{s}$

12. D Since the collision is elastic and the masses are equal, the bobs exchange velocities.

13. E The work done by friction brings the box to a stop, so it equals the initial kinetic energy of the box. $W = KE;\ F_f\Delta x = \frac{1}{2}mv^2;\ \mu mg\Delta x = \frac{1}{2}mv^2$

14. C https://en.wikipedia.org/wiki/Max_Planck

15. C It starts at a negative position and slows steadily until stopping and speeding up back toward its original position.

16. A $W = mg = 500\ N;\ F_{net} = F_N - W = -100\ N;\ a = \frac{F_{net}}{m} = -2\ \frac{m}{s^2}$

17. E $P = e\sigma AT^4; e\sigma A\ all\ stay\ the\ same, so\ P\ increases\ as\ T^4; (2T)^4 = 16P$

18. A An elastic collision is a collision in which there is no net loss in kinetic energy in the system as a result of the collision. Both momentum and kinetic energy are conserved quantities in elastic collisions.

19. B …Marconi being credited as the inventor of radio and sharing the 1909 Nobel Prize in Physics with Ferdinand Braun "in recognition of their contributions to the development of wireless telegraphy".

20. A $F_c = \frac{mv^2}{r} = 424\ N;\ F_f = \mu_s mg = 350\ N = \frac{mv^2}{r}; v = \sqrt{\frac{(F_f)(r)}{m}} = 10\ \frac{m}{s}$

21. B $KE = \frac{1}{2}mv^2; v = \sqrt{\frac{2KE}{m}} = 2.828\ \frac{m}{s}; p = mv = 0.707\ \frac{kg*m}{s}$

22. D $R_p = 4.0\ \Omega;\ R_{eq} = 12.0\ \Omega; I = 6.0\ A; V = IR = 72\ V$

23. D Any two launch angles that add to 90° will yield the same horizontal range for projectiles with the same launch speed.

24. A The total displacement for one complete oscillation is 0. Therefore, the average velocity of the mass for one complete oscillation is 0.

25. D The adiabatic index (γ) is the ratio of the specific heat capacity at constant pressure (C_P) to the specific heat capacity at constant volume (C_V). For an ideal diatomic gas, this ratio is 1.4.

26. C https://www.swpc.noaa.gov/phenomena/coronal-mass-ejections

27. B When going up, friction and gravity act in the same direction, opposing motion. When going down, friction opposes motion, while gravity acts in the direction of motion. Therefore, $a_{up} > a_{down}$. Since the distance is the same and $a_{up} > a_{down}$, then $t_{up} < t_{down}$.

28. C When the elevator accelerates upwards, the block will still float with 50% of its volume submerged. The acceleration changes the apparent weight of the block and the water, but the buoyant force remains the same.

29. A <u>Before collision</u>: $p_A = 30\ \frac{kg*m}{s};\ p_B = 0;\ KE_A = 45\ J;\ KE_B = 0$

<u>After collision</u>: $p_A = 0;\ p_B = 30\ \frac{kg*m}{s}; v_B = 5.0\ \frac{m}{s}; KE_A = 0;\ KE_B = 75\ J$

<u>Total mechanical energy</u>: 45 J + E_S = 75 J; <u>Spring</u>: $E_S = 30\ J = \frac{1}{2}k\Delta x^2$

30. A Alpha decay is a type of radioactive decay where an unstable, heavy nucleus emits an alpha particle (a helium-4 nucleus, consisting of two protons and two neutrons), reducing its atomic number by two and its mass number by four.

31. E Because the friction force is doubled (2 N), the net force is now 0. Therefore, there is no acceleration on the new mass.

32. A The normal force is the component of a contact force that is perpendicular to the surface that an object contacts.

33. B $For\ an\ adiabatic\ process: T_1V_1^{\gamma-1} = T_fV_2^{\gamma-1};\ T_f = T_1(\frac{V_1}{V_2})^{\gamma-1}$

$V_1 = \frac{1}{2}V\ and\ V_2 = V;\ T_f = T_1(\frac{1}{2})^{\gamma-1};\ T_f = T_1(\frac{1}{2})^{\frac{2}{3}}$

34. D $f_1 = n_1 \frac{v_1}{2L};\ f_2 = n_2 \frac{v_2}{2L};\ v_1 = \sqrt{\frac{T}{\mu}};\ v_2 = \sqrt{\frac{T}{4\mu}};\ f_1 = f_2;\ n_2 = 8$

35. A At the bottom of the loop, gravity is pulling downwards, but the centripetal force is now directed upwards, toward the center of the loop. The net force acting on the pilot is therefore downwards, causing them to feel heavier or pressed into their seat.

36. E Total kinetic energy is the sum of the kinetic energy plus the translational kinetic energy.

37. D $F\Delta t = m\Delta v; p = m\Delta v; \Delta p = 8\ \frac{kg*m}{s} - \left(-4\ \frac{kg*m}{s}\right) = 12\ \frac{kg*m}{s} = 12\ \text{N} \bullet \text{s}$

38. D When a conductor is charged, the free charges within it redistribute themselves until the electric field inside the conductor is zero. If there were a non-zero electric field inside the conductor, the free charges would experience a force and move, which would contradict the state of electrostatic equilibrium.

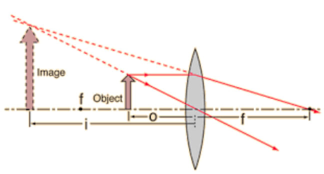
39. B N-type semiconductors are created by doping with impurities that have more valence electrons than the host semiconductor material (silicon has 4 valence electrons). Antimony (Sb), with its five valence electrons, is a common dopant used to create N-type semiconductors.

40. D $Q_{net} = Q_1 + Q_2 + Q_3 + Q_4;\ Q_2 = Q_4\ so\ Q_{net} = Q_1 + Q_3; e = \frac{W}{Q_{in}} = \frac{Q_1+Q_3}{Q_1}$

41. C At that point, the string will be moving up again to form another crest.

42. D The EM wave associated with this magnetic field travels along the +z direction from the argument in the cosine term. The magnetic field at the position and time given points along the +x direction since cos(0) = 1. The Poynting vector gives the direction of energy flow for the EM wave which is also the same as the direction of travel of the wave. Hence, writing that $\vec{S} \sim \vec{E}\ x\ \vec{B}$,we need to figure out $\overrightarrow{??}\ x\ \hat{x} = \hat{z}$**.** By Right-hand rules…$-\vec{y}\ x\ \hat{x} = -\hat{z}$ and so the electric field is directed along -y here.

43. C See:



44. C <u>Momentum after collision</u>: $p_y = \left(\frac{1}{2}M\right)(3V)\left(\frac{\sqrt{5}}{3}\right) = \frac{1}{2}MV\sqrt{5}$

<u>Total mass after collision</u>: $M + \frac{1}{2}M = \frac{3}{2}M$

<u>Total momentum after collision</u>: $p = \frac{3}{2}Mv_f = \frac{1}{2}MV\sqrt{5};\ v_f = \frac{V\sqrt{5}}{3}$

45. B $1\ eV = 1.6\ x\ 10^{-19}\ J = 1.6\ x\ 10^{-19}\ \frac{kg*m^2}{s^2};\ \frac{eV}{c} = \frac{\frac{kg*m^2}{s^2}}{\frac{m}{s}} = \frac{kg*m}{s};\ \frac{eV}{c^2} = kg$

46. A $P = \frac{V^2}{R};\ P_B = 4P_A;\ \therefore\ R_B = \frac{1}{4}R_A$

47. D See: https://en.wikipedia.org/wiki/Bohr_model for details

48. C $L' = L_o\sqrt{1 - \frac{v^2}{c^2}}$

49. E The electric field due to a positive charge points away from the charge, while the electric field due to a negative charge points towards the charge. At x=0, the electric fields from both charges have equal magnitude but opposite directions and thus cancel out, resulting in a net electric field of zero. At x=0, the distances from both charges are equal and the potential from one charge is positive, while the potential from the other charge is negative. These two potentials are equal in magnitude, so their sum is zero.

50. B $v = \lambda f;\ v_{air} = 340\ \frac{m}{s};\ v_{water} = 1481\ \frac{m}{s};$

$Frequency\ doesn't\ change, \therefore\ as\ v\ increases, so\ does\ \lambda.$