1. B Decompose the velocity vector into vertical and horizontal components. There is only acceleration in the negative vertical direction of magnitude g. The horizontal component is vcos(Θ) and the vertical is vsinΘ . We need to first solve for how long the object is in the air. Using the definition of acceleration, we get that the time to reach the apex is (vsinΘ)/g. Multiplying by 2 to get the total air time, we get time = (2 vsinΘ)/g. Multiply this by the horizontal velocity to get (2 v^2 sinΘ cosΘ)/g, which is also equivalent to answer choice by double angle identity
2. C Voltage is constant since the battery is there. Capacitance is cut in half since it is inversely proportional to plate separation. Thus charge is cut in half. Potential energy is capacitance times voltage squared over two. Thus potential energy is cut in half.
3. B Jimmy and Jack both cover 5/4 more than they did when Ahan finishes in order to Jack to finish the race. Thus Jimmy covers 5/6 of the race when Jack finishes.
4. A Power is equal to V^2/R. Since neither changes for the 6 ohm resistor branch, power output is the same.
5. C The time it would take to hit the target if there was no gravity is given by 150 m/100 m/s = 1.5 s During that time the ball falls vertically a distance of d = 1/2 gt^2 = 11.25 m
6. B Construct a picture as follows: Draw the 25 m/s vector and the 50 m/s vector such that the arrows point to the same point. Connect the tails of the vectors. This will represent the acceleration vector. Taking any point along the acceleration vector and connecting it to the point that connects the 25 and the 50 vector will depict the instantaneous velocity of the phone at some point along the path. Thus the smallest vector would be the altitude of the right triangle, or $10\sqrt{5}$ m/s
7. E The normal force provides the centripetal force. Friction is equal to the coefficient of friction times normal force. Thus we have $g=\mu\omega^2 r$. Solve for mu to get 1/9
8. D This is a simple infinite series question. Using the reciprocal of the sum of reciprocal rule for parallel branches. We can say that x = 2R +$\frac{1}{\frac{1}{R}+\frac{1}{x}}$ so multiplying everything by (R+x) and rearranging gives you $x^2-2Rx-2R^2=0$ Solving for x, you get D.
9. A An infinite series of springs connected in series will converge to a equivalent constant of 0. The equivalent constant 1/x where x is the number of springs in series diverges to zero.
10. A I assert that the solution to the problem is simply finding the maximum number of intersections n lines can have on a graph. Plot a graph of distance x versus time. Any time a line intersects, this implies a collision happens between the two beads. When the two beads collide, the velocities swap, meaning they essentially swap what line they are represented by on the graph. Do it for the 2, 3, 4 bead case and it becomes very obvious that this works.
11. B Power is equal to force times velocity or mav. This implies acceleration varies with velocity. If the kinetic energy is multiplied by a factor of 12, the velocity increases by a factor of $\sqrt{12}$ and the acceleration decreases by a factor of 1/$\sqrt{12}$. Thus we get answer choice
12. A Plug in 10 for f and 15 for s into the lens equation to get $\frac{1}{10}=\frac{1}{30}+\frac{1}{x}$. Solving, x is positive 15, so 15 real.

13. C Net force = ma so bmg-mg=ma+bma. So a = (b-1)/(b+1)g.
14. D The string will break if T > σA, where σ is the tensile strength and A is the cross sectional area, so v = $\sqrt{\frac{T}{M/L}} = \sqrt{\frac{\sigma AL}{M}} = \sqrt{\frac{\sigma}{\rho}} =$, where ρ is the density. This expression is independent of the length of the string, so the wave speed on the two strings is the same. Since v = fλ and the strings are the same length, they have the same fundamental frequency.
15. E Multiply the pyramid one by 6 to construct a cube of side length s and a electric potential found at the center of the cube. Deconstruct the cube into 8 equivalent cubes of side length s/2 with the corner being the point at which we find the electric potential. $\frac{0.18\rho s^2}{\varepsilon_0}=8 * \frac{0.18\rho(s/2)^2}{\varepsilon_0} = \frac{0.09\rho s^2}{\varepsilon_0}$.
16. D Using $V_f^2 - V_i^2 = 2ad$, we can find the acceleration. It is equal to 500000 m/s^2. Using the definition of acceleration, the time it takes to come to a stop is 1/500 of a second.
17. A Balance the torques (I divided out the g from both sides for sake of simple math) 5(50)=x(80). x=25/8+5=65/8 m
18. D First collision v= mv/3m. Second collision v= mv/4m. third collision v= mv. Multiply by the masses at rest to get impulse to the block. Thus it is D.
19. B The velocities simply swap since the masses are equal.
20. C Take the harmonic mean of the two speeds. This gives you C
21. D For the in-phase situation, the separation between the masses is constant, so the force of A on B is constant. In that case, only one spring exerts a varying force, and then the angular frequency must be given by $(\omega_1)^2$ = k/m For the out of phase situation, the separation between the objects is not constant, but there exists a point on the connecting spring that does not move. As such, either object can be though of moving under the influence of two springs in parallel, one with length L, the there with length L/2. That is equivalent to a spring with constant k in parallel with a spring of constant 2k. The net spring constant is then k + 2k = 3k. As such, the frequency is given by $(\omega_2)^2 = 3k/m = \sqrt{3}\ \omega_1$
22. D This will occur if the ramp is elevated enough so that the center of mass is no longer vertically above the ramp (draw a line straight down from the center of mass. If when it doesn't intersect the ramp anymore, you have hit the critical angle) i.e at a 60 degree angle. Thus mu must be tan60 degrees or D
23. A Using $V_f^2 - V_i^2 = 2ad$, we can find what the final velocity of the ball is when it hits the target. Substituting this in, we find that the final velocity is 40 m/s. This means the ball has been in the air for 6 seconds (using the definition of acceleration). Thus the ball has traveled 600 meters horizontally. Since the ball collides elastically with the target, the ball's path has essentially been flipped in the horizontal direction. So we find the total range and subtract out the 600 meters already traveled. We solved for the equation in question 1, so we plug in the values to get that the total range is 2000 meters. Thus the ball travels another 1400 meters, stopping 800 meters behind Kejin.
24. A Multiply change in temperature of the coefficient of thermal expansion and add to diameter to get A as the circumference.
25. A Plug into $1-(Q_{cold}/Q_{hot})$. 1-400/1000 is 3/5.

26. D This is simply an infinite geometric series with first term $\frac{2v_0}{g}$ and a common ratio of r. Thus you get D
27. C In order for the average speed to clock out at 50/3 m/s, the car needs to travel 10 meters in 3/5 of a second. Plugging this into x = .5at$^2 + vt$ gives us that a must be 100/9 meters per second.
28. D Plug this into question 1 to get D
29. A 2000(8.64)(100-T)=12000(4.32)(T-50) -> 2(100-T)=6(T-50). T= 62.5
30. A The final frequency is equal to $\frac{v-v_{0bs}}{v-v_{sou}}$. This $\frac{340-30}{340-10}$ gives us answer choice 493.