ANSWERS - AP Physics Multiple Choice Practice – Momentum and Impulse

	Solution	Answer
1.	Based on $Ft = m\Delta v$, doubling the mass would require twice the time for same momentum change	D
2.	Two step problem. I) find velocity after collision with arrow. $m_a v_{ai} = (m_a+m_{b)}\, v_f$ $v_f = mv / (m+M)$ II) now use energy conservation. $K_i = U_{sp(f)}$ $\frac{1}{2}(m+M)v_f^2 = \frac{1}{2}k\,\Delta x^2$, sub in v_f from I	E
3.	Use $J=\Delta p$ $Ft=\Delta p$ $(100)t=200$ $t=2$	D
4.	Definition. Impulse, just like momentum, needs a direction and is a vector	C
5.	Since $p=mv$, by doubling v you also double p	D
6.	Since the momentum is the same, that means the quantity $m_1v_1 = m_2v_2$. This means that the mass and velocity change proportionally to each other so if you double m_1 you would have to double m_2 or v_2 on the other side as well to maintain the same momentum. Now we consider the energy formula $KE= \frac{1}{2} mv^2$ since the v is squared, it is the more important term to increase in order to make more energy. So if you double the mass of 1, then double the velocity of 2, you have the same momentum but the velocity of 2 when squared will make a greater energy, hence we want more velocity in object 2 to have more energy.	C
7.	Due to momentum conservation, the total before is zero therefore the total after must also be zero	E
8.	Definition. $J_{net} = \Delta p$	B
9.	Perfect inelastic collision. $m_1v_{1i} + m_2v_{2i} = m_{tot}(v_f)$ … $(75)(6) + (100)(–8) = (175)\, v_f$	A
10.	Perfect inelastic collision. $m_1v_{1i} = m_{tot}(v_f)$ … $(30)(4) = (40)v_f$	A
11.	Perfect inelastic collision. $m_1v_{1i} = m_{tot}(v_f)$ … $(5000)(4) = (13000)v_f$	C
12.	Energy is conserved during fall and since the collision is elastic, energy is also conserved during the collision and always has the same total value throughout.	E
13.	To conserve momentum, the change in momentum of each mass must be the same so each must receive the same impulse. Since the spring is in contact with each mass for the same expansion time, the applied force must be the same to produce the same impulse.	C
14.	Momentum is equivalent to impulse which is Ft	A
15.	Use $J=\Delta p$ $J = mv_f – mv_i$ $J = (0.5)(– 4) – (0.5)(6)$	C
16.	Perfect inelastic collision. $m_1v_{1i} = m_{tot}(v_f)$ … $(2m)(v) = (5m)\, v_f$	B
17.	First of all, if the kinetic energies are the same, then when brought to rest, the non conservative work done on each would have to be the same based on work-energy principle. Also, since both have the same kinetic energies we have $\frac{1}{2} m_1v_1^2 = \frac{1}{2} m_2v_2^2$ … since the velocity is squared an increase in mass would need a proportionally smaller decrease in velocity to keep the terms the same and thus make the quantity mv be higher for the larger mass. This can be seen through example: If mass m_1 was double mass m_2 its velocity would be $v / \sqrt{2}$ times in comparison to mass m_2's velocity. So you get double the mass but less than half of the velocity which makes a larger mv term.	E

18. Perfect inelastic collision. $m_1v_{1i} = m_{tot}(v_f)$ … $(m)(v) = (3m)\ v_f$ A

19. Perfect inelastic collision. $m_1v_{1i} = m_{tot}(v_f)$ … $(1200)(7) = (2800)v_f$ C

20. Explosion. $p_{before} = 0 = p_{after}$ … $0 = m_1v_{1f} + m_2v_{2f}$ … $0 = (50)(v_{1f}) + (2)(10)$ B

21. Since p=mv and both p and v are vectors, they must share the same direction A

22. Explosion, momentum before is zero and after must also be zero. To have equal momentum the heavier student must have a much smaller velocity and since that smaller velocity is squared it has the effect of making the heavier object have less energy than the smaller one C

23. Use $J=\Delta p$ $Ft = mv_f - mv_i$ $Ft = m(v_f - v_i)$ … *note: since m is not given we will plug in F_g / g with g as 10 to be used in the impulse equation*.
$(24000)(t) = (15000 / 10\text{m/s}^2)(36-12)$ C

24. This is a rather involved question. First find speed of impact using free fall or energy. Define up as positive and Let v_1 = trampoline impact velocity and v_2 be trampoline rebound velocity. With that $v_1 = \sqrt{80}$ and $v_2 = -\sqrt{80}$. Now analyze the impact with the pad using $J_{net} = \Delta p$
$F_{net}\, t = mv_2 - mv_1$ At this point we realize we need the time in order to find the F_{net} and therefore cannot continue. If the time was given, you could find the F_{net} and then use $F_{net} = F_{pad} - mg$ to find F_{pad}. E

25. Based on momentum conservation both carts have the same magnitude of momentum "mv" but based on $K = ½\, m\, v^2$ the one with the larger mass would have a directly proportional smaller velocity that then gets squared. So by squaring the smaller velocity term it has the effect of making the bigger mass have less energy. This can be shown with an example of one object of mass m and speed v compared to a second object of mass 2m and speed v/2. The larger mass ends up with less energy even through the momenta are the same. B

26. Use $J=\Delta p$ $Ft = mv_f - mv_i$ $Ft = m(v_f - v_i)$ $F\,(0.03) = (0.125)(-6.5 - 4.5)$ D

27. Momentum conservation. $p_{before} = p_{after}$ $m_1v_{1i} = m_1v_{1f} + m_2v_{2f}$ $(0.1)(30) = (0.1)(20)+(m_a)(2)$ B

28. Perfect inelastic collision. $m_1v_{1i} + m_2v_{2i} = m_{tot}(v_f)$ … $(2000)(10) + (3000)(-5) = (5000)\ v_f$ A

29. Kinetic energy has no direction and based on $K = ½\, m\, v^2$ must always be + C

30. A 2d collision must be looked at in both x-y directions always. Since the angle is the same and the v is the same, v_y is the same both before and after therefore there is no momentum change in the y direction. All of the momentum change comes from the x direction.
$v_{ix} = v\cos\theta$ and $v_{fx} = -v\cos\theta$. $\Delta p = mv_{fx} - mv_{ix}$ … $-mv\cos\theta - mv\cos\theta$ E

31. Explosion. $p_{before} = 0 = p_{after}$ … $0 = m_1v_{1f} + m_2v_{2f}$ … $0 = (7)(v_{1f}) + (5)(0.2)$ B

32. In a circle at constant speed, work is zero since the force is parallel to the incremental distance moved during revolution. Angular momentum is given by mvr and since none of those quantities are changing it is constant. However the net force is NOT = MR, its Mv^2/R D

33. Since the momentum before is zero, the momentum after must also be zero. Each mass must have equal and opposite momentum to maintain zero total momentum. E

34. In a perfect inelastic collision with one of the objects at rest, the speed after will always be less no matter what the masses. The 'increase' of mass in 'mv' is offset by a decrease in velocity D

35. Since the total momentum before and after is zero, momentum conservation is not violated, however the objects gain energy in the collision which is not possible unless there was some energy input which could come in the form of inputting stored potential energy in some way. B

36. The plastic ball is clearly lighter so anything involving mass is out, this leaves speed which makes sense based on free-fall B

37. Perfect inelastic collision. $m_1v_{1i} = m_{tot}(v_f)$ … $(m)(v) = (m+M)\ v_f$ E

38. As the cart moves forward it gains mass due to the rain but in the x direction the rain does not provide any impulse to speed up the car so its speed must decrease to conserve momentum C

39. Angular momentum is given by the formula L = mvr = (2)(3)(4) E

40. 2D collision. Analyze the y direction. Before $p_y = 0$ so after p_y must equal 0. A
$0 = m_1v_{1fy} + m_2v_{2fy}$ $\quad 0 = (0.2)(1) + (0.1)(V_{2fy})$

41. Momentum increases if velocity increases. In a d-t graph, III shows increasing slope (velocity) B

42. The net force is zero if velocity (slope) does not change, this is graphs I and II C

43. Since the impulse force is applied in the same direction (60°) as the velocity, we do not need to use components but use the 60° inclined axis for the impulse momentum problem. In that direction. $J = \Delta p$ $\quad J = mv_f - mv_i = m(v_f - v_i) = (0.4)(0 - 5)$ C

44. Initially, before the push, the two people are at rest and the total momentum is zero. After, the total momentum must also be zero so each man must have equal and opposite momenta. C

45. Since the initial object was stationary and the total momentum was zero it must also have zero total momentum after. To cancel the momentum shown of the other two pieces, the 3m piece would need an x component of momentum $p_x = mV$ and a y component of momentum $p_y = mV$ giving it a total momentum of $\sqrt{2}\ mV$ using Pythagorean theorem. Then set this total momentum equal to the mass * velocity of the 3rd particle. D
$\sqrt{2}\ mV = (3m)\ V_{m3}$ and solve for V_{m3}

46. None of the statements are true. I) it is accelerating so is not in equilibrium, II) Its acceleration is –9.8 at all times, III) Its momentum is zero because its velocity is momentarily zero, IV) Its kinetic energy is also zero since its velocity is momentarily zero. E

47. Its does not matter what order to masses are dropped in. Adding mass reduces momentum proportionally. All that matters is the total mass that was added. This can be provided by finding the velocity after the first drop, then continuing to find the velocity after the second drop. Then repeating the problem in reverse to find the final velocity which will come out the same C

48. Stupid easy. Find slope of line A

49. Increase in momentum is momentum change which C

50. Basic principle of impulse. Increased time lessens the force of impact. E

51. Explosion. $p_{before} = 0 = p_{after}$ … $0 = m_1v_{1f} + m_2v_{2f}$ … $0 = m_1(5) + m_2(-2)$ B

52. Perfect inelastic collision. $m_1v_{1i} + m_2v_{2i} = m_{tot}(v_f)$ … $Mv + (-2Mv) = (3M)\ v_f$ gives $v_f = v/3$. Then to find the energy loss subtract the total energy before – the total energy after D
$[\ \frac{1}{2} Mv^2 + \frac{1}{2} (2M)v^2\ ] - \frac{1}{2} (3M)\ (v/3)^2 = 3/6\ Mv^2 + 6/6\ Mv^2 - 1/6\ Mv^2$

53. 2D collision. The y momentums are equal and opposite and will cancel out leaving only the x momentums which are also equal and will add together to give a total momentum equal to twice the x component momentum before hand. $p_{before} = p_{after}$ $2m_o v_o \cos 60 = (2m_o) v_f$ — B

54. Angular momentum is given by $L = mvr = mva$ — B

55. Perfect inelastic collision. $m_1 v_{1i} = m_{tot}(v_f)$ … $(4)(6) = (8)v_f$ — C

56. Perfect inelastic collision. $m_1 v_{1i} = m_{tot}(v_f)$ … $(8)(3) = (12)v_f$ — B

57. First use the given kinetic energy of mass M1 to determine the projectile speed after. — D
$K = ½M_1 v_{1f}^2$ … $v_{1f} = \sqrt{(2K/M_1)}$. Now solve the explosion problem with $p_{before}=0 = p_{after}$.
Note that the mass of the gun is $M_2–M_1$ since M_2 was given as the total mass.
$0 = M_1 v_{1f} + (M_2–M_1)v_{2f}$ … now sub in from above for v_{1f} .
$M_1(\sqrt{(2K/M_1)}) = – (M_2–M_1) v_{2f}$ and find v_{2f} … $v_{2f} = – M_1(\sqrt{(2K/M_1)}) / (M_2–M_1)$.
Now sub this into $K_2 = ½ (M_2–M_1) v_{2f}^2$ and simplify

58. Since there is no y momentum before, there cannot be any net y momentum after. The balls have equal masses so you need the y velocities of each ball to be equal after to cancel out the momenta. By inspection, looking at the given velocities and angles and without doing any math, the only one that could possibly make equal y velocities is choice D — D

59. Definition. $J_{net} = \Delta p$ $F_{net}\, t = \Delta p$ — A

60. Explosion with initial momentum. $p_{before} = p_{after}$ $mv_o = m_a v_{af} + m_b v_{bf}$ — E
$mv_o = (2/5\ m)(– v_o / 2) + (3/5\ m)(v_{bf})$ … solve for v_{bf}

61. The area of the Ft graph is the impulse which determines the momentum change. Since the net impulse is zero, there will be zero total momentum change. — C

62. Perfect inelastic collision. $m_1 v_{1i} + m_2 v_{2i} = m_{tot}(v_f)$ … $(m)(v) + (2m)(v / 2) = (3m)v_f$ — C

63. The total momentum vector before must match the total momentum vector after. Only choice E has a possibility of a resultant that matches the initial vector. — E

64. Since the angle and speed are the same, the x component velocity has been unchanged which means there could not have been any x direction momentum change. The y direction velocity was reversed so there must have been an upwards y impulse to change and reverse the velocity. — E

65. Simply add the energies $½ (1.5)(2)^2 + ½ (4)(1)^2$ — B

66. Total momentum before must equal total momentum after. Before, there is an x momentum of (2)(1.5)=3 and a y momentum of (4)(1)=4 giving a total resultant momentum before using the Pythagorean theorem of 5. The total after must also be 5. — C

67. Just as linear momentum must be conserved, angular momentum must similarly be conserved. Angular momentum is given by $L = mvr$, so to conserve angular momentum, these terms must all change proportionally. In this example, as the radius decreases the velocity increases to conserve momentum. — A

68. To find the breaking force, use impulse-momentum. $J = \Delta p$ $Ft = mv_f - mv_i$ D

$F(5) = 0 - (900)(20)$ $F = -3600$ N

The average velocity of the car while stopping is found with $\bar{v} = \frac{v_i + v_f}{2}$ = 10 m/s

Then find the power of that force $P = F\bar{v}$ = (3600)(10) = 36000 W

69. Each child does work by pushing to produce the resulting energy. This kinetic energy is input through the stored energy in their muscles. To transfer this energy to each child, work is done. The amount of work done to transfer the energy must be equal to the amount of kinetic energy gained. Before hand, there was zero energy so if we find the total kinetic energy of the two students, that will give us the total work done. First, we need to find the speed of the boy using momentum conservation, explosion: E

$p_{before} = 0 = p_{after}$ $0 = m_b v_b + m_g v_g$ $0 = (m)(v_b) = (2m)(v_g)$ so $v_b = 2v$

Now we find the total energy $K_{tot} = K_b + K_g = ½\ m(2v)^2 + ½\ 2m(v)^2 = 2mv^2 + mv^2 = 3mv^2$

70. Since it is an elastic collision, the energy after must equal the energy before, and in all collisions momentum before equals momentum after. So if we simply find both the energy before and the momentum before, these have the same values after as well. $p = Mv$, $K = ½\ Mv^2$ A

71. The area under the F-t graph will give the impulse which is equal to the momentum change. With the momentum change we can find the velocity change. C

J = area = 6 Then $J = \Delta p = m\Delta v$ $6 = (2)\Delta v$ $\Delta v = 3$ m/s

72. This is a 2D collision. Before the collision, there is no y momentum, so in the after condition the y momenta of each disk must cancel out. In choice B, both particles would have Y momentum downwards making a net Y momentum after which is impossible. B

73. This is the same as question 30 except oriented vertically instead of horizontally. E