ANSWERS - AP Physics Multiple Choice Practice – Dynamics

SECTION A – Linear Dynamics

	Solution	Answer
1.	As T_2 is more vertical, it is supporting more of the weight of the ball. The horizontal components of T_1 and T_2 are equal.	C
2.	Normal force is perpendicular to the incline, friction acts up, parallel to the incline (opposite the motion of the block), gravity acts straight down.	E
3.	$\Sigma F = ma$; $mg\sin\theta - f = ma$	C
4.	The "diluted" force between objects is the applied force times the ratio of the mass behind the rope to the total mass being pulled. This can be derived from $a = F/m_{total}$ and $F_T = m_{\text{behind the rope}}a$	E
5.	$\Sigma F = ma$; $mg - bv = ma$	B
6.	$F_f = \mu F_N$ where F_N is found from $\Sigma F_y = 0 = (F_N - mg - T\sin\theta)$	A
7.	$\Sigma F_y = 0 = F\sin\theta + F_N - W$	B
8.	The bottom of the rope supports the box, while the top of the rope must support the rope itself and the box.	E
9.	The vertical components of the tension in the rope are two equal upward components of $T\cos\theta$, which support the weight. $\Sigma F_y = 0 = 2T\cos\theta - W$	D
10.	$F = mg = kx$ (the negative sign merely indicates the direction of the spring force relative to the displacement)	E
11.	$\Sigma F_{external} = m_{total}a$; mg is the only force acting from outside the system of masses so we have $mg = (4m)a$	B
12.	$W = mg$	D
13.	$F_N = mg\cos\theta$, $\cos\theta$ = adjacent/hypotenuse = 4/5	C
14.	Three vectors add to zero if they form the sides of a triangle, there is no requirement they be equal or parallel, though it is possible.	A
15.	Any curvature of the line in a d-t graph indicates a non-zero acceleration	C
16.	Motion in a straight line does not mean the speed is constant. Simple harmonic motion is a constantly changing velocity and can only occur with an acceleration. Motion in a circle requires centripetal acceleration.	E
17.	$\Sigma F = ma$; $F_T - mg = ma$; Let F_T = 50 N (the maximum possible tension) amd m = W/g = 3 kg	B
18.	The sum of the tensions in the chains (250 N + T_{left}) must support the weight of the board and the person (125 N + 500 N)	B
19.	From symmetry, each chain supports half of the weight of the board (62.5 N), The weight of the person is then split between the chains with the left chain holding 375 N – 62.5 N = 312.5 N and the right chain supporting 250 N – 62.5 N = 187.5 N or 3/5 of the tension in the left chain. This means if the person sits a distance x from the left end, they sit a distance (5/3)x from the right end. This gives $x + (5/3)x = 4$ m	B
20.	$\Sigma F = ma$; 10 N – (30 N cos60º) = (10 kg)a	A

21. Since the same force acts for the same time in each direction, the velocity in each direction is the same. The vector should then point at a 45º angle in the first quadrant. C

22. Consider that no part of the system is in motion, this means at each end of the rope, a person pulling with 100 N of force is reacted to with a tension in the rope of 100 N. C

23. As v is proportional to t^2 and a is proportional to $\Delta v/t$, this means a should be proportional to t E

24. $\Sigma F_y = 0 = T\sin 30^\circ - mg$ D

25. F = ma gives 20 N = (5 kg)a or an acceleration of 4 m/s^2. The 2 kg block is accelerating due to the contact force from the 3 kg block $F_{contact} = ma = (2\ kg)(4\ m/s^2) = 8\ N$. The 2 kg pushes back on the 3 kg block with a force equal in magnitude and opposite in direction. A

26. The direction of the force is the same as the direction of the acceleration, which is proportional to $\Delta v = v_f + (-v_i)$ B

27. $\Sigma F_{external} = m_{total}a$ gives $(0.90\ kg \times 10\ m/s^2) - (0.60\ kg \times 10\ m/s^2) = (1.5\ kg)a$ D

28. Each spring supports half of the weight, or 6 N. F = kx A

29. gravity acts downward D

30. At constant speed $\Sigma F = 0$; The forces acting parallel to the incline are F (up), F_f (down) and $mg\sin\theta$ (down), which gives $F - F_f - mg\sin\theta = 0$, where $F_f = \mu F_N = \mu mg\cos\theta$ and $\cos\theta = 4/5$ B

31. $\Sigma F = ma = F\cos\phi - f$ D

32. $f = \mu F_N$ where $F_N = mg - F\sin\theta$ E

33. The string pulling all three masses (total 6*m*) must have the largest tension. String A is only pulling the block of mass 3*m* and string B is pulling a total mass of 5*m*. C

34. At t = 2 s the force is 4 N. F = ma B

35. The upward component of the slanted cord is 300 N to balance the weight of the object. Since the slanted cord is at an angle of 45º, it has an equal horizontal component. The horizontal component of the slanted cord is equal to the tension in the horizontal cord. D

36. The normal force must point perpendicular to the surface and the weight must point down. In order to accelerate up the ramp, there must be an applied force up the ramp. If the box is accelerating up the ramp, friction acts down the ramp, opposite the motion. E

37. The normal force must point perpendicular to the surface and the weight must point down. If the box is at rest on the ramp, friction acts up the ramp, opposing the tendency to slide down C

38. The normal force must point perpendicular to the surface and the weight must point down. If the box is sliding down at constant speed, friction acts up the ramp, opposing the motion C

39. $\Sigma F_{external} = m_{total}a$ gives (Mg) – (mg) = (M + m)a E

40. To keep the box from slipping, friction up the wall must balance the weight of the block, or F_f = mg, where $F_f = \mu F_N$ and F_N = the applied force F. This gives $\mu F = mg$ C

41. $\Sigma F_{external} = m_{total}a$ gives (mg) – (10 N) = (m + 1 kg)(5 m/s^2) A

42. Friction opposes the motion of the block and therefore points to the left. The normal force is found from $\Sigma F_y = 0 = F_N - mg - F\sin\theta$ and the force of friction $F_f = \mu F_N$ E

43. When an object exerts a force **on a second object**, the second object exerts an equal and opposite force back **on the first object**. C

44. Since P is at an upward angle, the normal force is decreased as P supports some of the weight. Since a component of P balances the frictional force, P itself must be larger than f. — A

45. Newton's 2nd law applied to an object sliding to rest gives $\Sigma F = -F_f = -\mu F_N = ma$. On a horizontal surface, $F_N = mg$ and we have $-\mu mg = ma$, or $a = -\mu g$. Use this acceleration with $v_f^2 = v_i^2 + 2ad$. — D

46. $F = ma = m\Delta v/t$ — C

47. $\Sigma F = ma$; $F_{cable} - mg = ma = m(-2\ m/s^2)$ — C

48. The force of friction $= \mu F_N = 0.2 \times 10\ kg \times 9.8\ m/s^2 = 19.6\ N$, which is greater than the applied force, which means the object is accelerating to the left, or slowing down — A

49. $F = ma$ gives $36\ N = (24\ kg)a$ or an acceleration of $1.5\ m/s^2$. The 20 kg block is accelerating due to the contact force from the 4 kg block $F_{contact} = ma = (20\ kg)(1.5\ m/s^2) = 30\ N$. — D

50. The upward component of the tension is $T_{up} = T\sin\theta$, where θ is the angle to the horizontal. This gives $T = T_{up}/\sin\theta$. Since the upward components are all equal to one half the weight, the rope at the smallest angle (and the smallest value of $\sin\theta$) will have the greatest tension, and most likely break — B

51. $\Sigma F_{external} = m_{total}a$ gives $(3.0\ kg \times 10\ m/s^2) - (1.5\ kg \times 10\ m/s^2) = (4.5\ kg)a$ — C

52. From the 1 kg block: $F = ma$ giving $a = 2\ m/s^2$. For the system: $F = (4\ kg)(2\ m/s^2)$ — E

53. For three forces in equilibrium, any one of the forces is equal and opposite to the resultant of the other two forces. — D

54. Elevator physics: F_N represents the scale reading. $\Sigma F = ma$; $F_N - mg = ma$, or $F_N = m(g + a)$. The velocity of the elevator is irrelevant. — B

55. F = ma, if F is doubled, a is doubled. If m is halved, a will be doubled. — D

56. Newton's third law — C

57. $F = ma$ gives $24\ N = (12\ kg)a$ or an acceleration of $2\ m/s^2$. The 3 kg block is accelerating due to the tension in the rope $F_T = ma = (3\ kg)(2\ m/s^2) = 6\ N$. — B

58. Inertia is mass — E

59. The normal force is $mg\cos\theta$. For a horizontal surface, $F_N = mg$. At any angle $F_N < mg$ and F_f is proportional to F_N. — C

60. $F = ma$, where $m = W/g = 10\ kg$ — B

61. Newton's 2nd law applied to an object sliding to rest gives $\Sigma F = -F_f = -\mu F_N = ma$. On a horizontal surface, $F_N = mg$ and we have $-\mu mg = ma$, or $a = -\mu g$. Using this acceleration with $v_f^2 = v_i^2 + 2ad$ gives $d = v_i^2/2\mu g$. There is no dependence on mass. — B

62. Newton's 2nd law applied to an object sliding to rest gives $\Sigma F = -F_f = -\mu F_N = ma$. On a horizontal surface, $F_N = mg$ and we have $-\mu mg = ma$, or $a = -\mu g$. Using this acceleration with $v_f^2 = v_i^2 + 2ad$ gives $d = v_i^2/2\mu g$. d is proportional to v_i^2 — E

63. $F = ma$ and $v_f^2 = 0\ m/s = v_i^2 + 2ad$ — B

64. The normal force on an incline is $mg\cos\theta$. The component of gravity acting down the incline is $mg\sin\theta$. The coefficient of friction is minimized when static friction is at its maximum value, or $\mu_s F_N$. Keeping the block at rest requires $mg\sin\theta = F_f = \mu mg\cos\theta$, or $\mu = \tan\theta$ — C

65.	The maximum resultant possible from the sum of any two vectors is the sum of the magnitudes. The minimum resultant possible is the difference between the magnitudes. Forces of 6 N and 10 N produce a maximum resultant of 16 N and a minimum of 4 N.	C
66.	An apple is approximately 100 g. It is important to have a sense of basic values of measurement.	D
67.	$\Sigma F = ma$. The component of gravity acting down the incline is $mg\sin\theta$, which gives $a = g\sin\theta$	C
68.	$\Sigma F = ma$; $mg\sin\theta - F_f = ma$	B
69.	Slope = $\Delta y/\Delta x$ = Weight/mass = acceleration due to gravity	D
70.	Newton's second law applied to m_1: $T = m_1a$, or $a = T/m_1$, substitute this into Newton's second law for the hanging mass: $m_2g - T = m_2a$	E
71.	$\Sigma F_y = 0$ gives $F_N + (250\text{ N} \sin30^o) - mg = 0$, or $F_N = 365$ N. To move at constant speed, the force of friction must balance the horizontal component of the applied force $F\cos\theta = 216.5\text{ N} = \mu F_N$	D
72.	String B is pulling both masses so $F_B = (6\text{ kg})(12\text{ m/s}^2)$	A
73.	String A is only pulling the 4 kg mass so $F_A = (4\text{kg})(12\text{ m/s}^2)$	B
74.	$F_{net} = ma$	C
75.	Elevator physics: R represents the scale reading. $\Sigma F = ma$; $R - mg = ma$, or $R = m(g + a)$. This ranks the value of R from largest to smallest as accelerating upward, constant speed, accelerating downward	A
76.	$\Sigma F = ma$ for the whole system gives $F - \mu(3m)g = (3m)a$ and solving for a gives $a = (F - 3\mu mg)/3m$. For the top block, $F_m = ma = m[(F - 3\mu mg)/3m]$	A
77.	$m \times a = kg \times m/s^2$	D
78.	The normal force comes from the perpendicular component of the applied force which is $F\cos\theta = 50$ N. The maximum value of static friction is then $\mu F_N = 25$ N. The upward component of the applied force is $F\sin\theta = 87$ N. $\Sigma F_y = F_{up} - mg = 87\text{ N} - 60\text{ N} > 25$ N. Since the net force on the block is great than static friction can hold, the block will begin moving up the wall. Since it is in motion, kinetic friction is acting opposite the direction of the block's motion	D
79.	Since P is at a downward angle, the normal force is increased. Since a component of P balances the frictional force, P itself must be larger than f.	A
80.	Since the force is applied horizontally, the mass has no effect.	C
81.	Newton's third law	E
82.	If they are not moving, the net force must be zero. While the book and crate are pushing each other apart, there is friction from the table pointing inward against each object on the table to keep them at rest.	C
83.	The only force in the direction of the crate's acceleration is the force of friction from the sleigh	B
84.	Elevator physics: F_N represents the scale reading. $\Sigma F = ma$; $F_N - mg = ma$, or $F_N = m(g + a)$. When $F_N > mg$, the elevator is accelerating upward (a is positive)	A
85.	Changing direction (choices A and C (the astronaut is still orbiting the earth!)) cannot occur with a zero net force. Choices B and D represent accelerated motion.	E

86. Given that the box accelerates toward Ted, Ted's force must be greater than Mario's force plus the force of friction. Since Mario's force is ½ of Ted's force, the force of frction must be less than half of Ted's force. A

87. For a Newton's third law pair, just switch the nouns. C

88. The component of gravity acting down the incline (+x) is $mg\sin\theta$ and the component perpendicularly intothe incline (–y) is $mg\cos\theta$. 36.9º indicates a 3-4-5 triangle. A

89. $\Sigma F = ma$; $F – mg = m(5g)$ or $F = 6mg$ A

90. $\Sigma F_y = F\sin\theta + F_N – mg = 0$, which gives $F_N = 170$ N. The force of friction is equal to the horizontal component of the force applied by the student which is $F\cos\theta = 86.6$N. $F_f = \mu F_N$ C

91. constant speed means $F_{net} = 0$ N A

92. As the initial and final velocities and the displacement are given, as well as an indication that the acceleration is constant, this is merely a kinematics problem. $v_f^2 = v_i^2 + 2ad$ E

93. The maximum value of static friction in this case is $\mu_s F_N = 120$ N. Since the person is pushing with only 60 N of force, the box remains at rest. C

94. Between the lower block and the tabletop, there is a force of friction to the left of maximum magnitude $\mu(2W)$ as both blocks are pushing down on the tabletop. There is also a force of friction acting to the left on the upper surface of the lower block due to the upper block of maximum magnitude μW. The total maximum static frictional force holding the lower block in place is therefore $\mu(2W) + \mu W$ E

95. The normal force on the block can be found from $\Sigma F_y = 0 = F_N – mg\cos\theta – F$. The force of friction necessary to hold the block in place is $mg\sin\theta$. Setting the force of friction equal to $mg\sin\theta$ gives $\mu F_N = mg\sin\theta = \mu(F + mg\cos\theta)$ E

96. In equilibrium, $mg = kx$ and the equilibrium position $x = mg/k$. In an accelerating elevator, we can just adjust gravity to its effective value $g_{eff} = g + a$, thus making the new equilibrium position mg_{eff}/k C

97. This is a tricky one. In order to move the car forward, the rear tires roll back against the ground, the force of friction pushing forward on the rear tires. The front tires, however, are not trying to roll on their own, rather they begin rolling due to the friction acting backward, increasing their rate of rotation A

98. Gravity is still the only force acting vertically so we can find the total time in the air from kinematics: $v_y = 0$ at the top $= v_0\sin\theta – gt$ giving t (to the top) $= v_0\sin\theta/g$ and the total time is twice the time to the top, or $2v_0\sin\theta/g$. In this time, the ball is also accelerating horizontally (think of it as a "sideways" gravity) and in this time, should return to its starting location. Using $x = 0 = (v_0\cos\theta)t + ½ at^2$, where $a = F_0/m$ and t is found above, we can solve for θ B

99. The external forces acting on the system of masses are the weights of block 1 (pulling the system to the left), the weight of block 3 (pulling the system to the right) and the force of friction on block 2 (pulling the system to the left with a magnitude $\mu F_N = \mu m_2 g$) $\Sigma F_{external} = m_{total}a$ gives $(m_1g – \mu m_2g – m_3g) = (m_1 + m_2 + m_3)a$ E

100. $F = ma$ gives 30 N = (12 kg)a or an acceleration of 2.5 m/s^2. The 5 kg block is accelerating due to the tension in the rope $F_T = ma = (5\text{ kg})(2.5\text{ m/s}^2) = 12.5$ N. C

101. $\Sigma F_{external} = m_{total}a$ gives $(5.0\text{ kg} \times 10\text{ m/s}^2) – (3\text{ kg} \times 10\text{ m/s}^2) = (8\text{ kg})a$ E

102. As they are all at the same position after 8 seconds, they all have the same average velocity D

103. Car A decelerates with the same magnitude that C accelerates. Car B is moving at constant speed, which means $F_B = 0$. B

104. When falling with terminal velocity, the force of air resistance equals your weight, regardless of the speed. E

105. For each case, $\Sigma F_{external} = m_{total}a$ gives $Mg - mg = (M + m)a$, or $a = \frac{M-m}{M+m}g$. A

106. The two ends of the light string must have the same tension, eliminating choices A, C and D. If choice E was correct, both masses would be accelerating downward and T_A must be greater than the weight of block A. B

107. If $F = ma$, then $m = F/a$. For the second object $m' = 2F/5a = 2/5(F/a) = (2/5)m$ A

108. $\Sigma F_{external} = m_{total}a$ gives $(M + m)g - Mg = (2M + m)a$ A

109. As the entire system moves as one, $F = (3m)a$, or $a = F/(3m)$. The force of friction acting on block 1 is the force moving block 1 and we have $\mu mg = m(F/(3m))$ E

110. $F = ma = m\Delta v/t$ B

111. This is really no different than any other incline problem. The normal force on an incline with no other forces acting into the incline is $mg\cos\theta$ E

112. Since the system is moving at constant velocity, m_1 is pushing m_2 and m_3 with a force equal to the force of friction acting on those two blocks, which is $\mu(F_{N2} + F_{N3})$ A

113. $\Sigma F_{external} = m_{total}a$ gives $(5\text{ kg} \times 9.8\text{ m/s}^2) - F_f = (10\text{ kg})a$, where F_f is the force of friction acting on the 5 kg block on the table: $\mu mg = 0.2 \times 5\text{ kg} \times 9.8\text{ m/s}^2 = 9.8\text{ N}$ D

SECTION B – Circular Motion

1.	Newton's third law	B
2.	$F = mv^2/r$; $v = \sqrt{\frac{Fr}{m}}$; all other variables being constant, if r is quadrupled, v is doubled	D
3.	With acceleration south the car is at the top (north side) of the track as the acceleration points toward the center of the circular track. Moving east indicates the car is travelling clockwise. The magnitude of the acceleration is found from $a = v^2/r$	A
4.	The frictional force acts as the centripetal force (toward the center)	D
5.	Acceleration occurs when an object is changing speed and/or direction	D
6.	Velocity is tangential, acceleration points toward the center of the circular path	B
7.	To move in a circle, a force directed toward the center of the circle is required. While the package slides to the right in the car, it is actually moving in its original straight line path while the car turns from under it.	E
8.	$a = v^2/r$ and $v = 2\pi r/T$ giving $a = 4\pi^2 r/T^2$	B
9.	Once projected, the ball is no longer subject to a force and will travel in a straight line with a component of its velocity tangent to the circular path and a component outward due to the spring	E
10.	There is a normal force directed upward and a centripetal force directed inward.	D
11.	$a = v^2/r$ where $v = 2\pi rf$ and $f = 2.0$ rev/sec	D
12.	At Q the ball is in circular motion and the acceleration should point to the center of the circle. At R, the ball comes to rest and is subject to gravity as in free-fall.	C
13.	The net force and the acceleration must point in the same direction. Velocity points tangent to the objects path.	D
14.	The centripetal force is provided by the spring where $F_C = F_s = kx$	B
15.	In the straight sections there is no acceleration, in the circular sections, there is a centripetal acceleration	B
16.	Once the stone is stuck, it is moving in circular motion. At the bottom of the circle, the acceleration points toward the center of the circle at that point.	A
17.	Feeling weightless is when the normal force goes to zero, which in only possible going over the top of the hill where mg (inward) – F_N (outward) = mv^2/R. Setting F_N to zero gives a maximum speed of $\sqrt{gR}$	A
18.	Centripetal force points toward the center of the circle	B
19.	While speed may be constant, the changing direction means velocity cannot be constant as velocity is a vector	B
20.	$F = mv^2/r$. $F_{new} = (2m)(2v)^2/(2r) = 4(mv^2/r) = 4F$	D
21.	Assuming the track is circular at the bottom, the acceleration points toward the center of the circular path	A
22.	Average speed = (total *distance*)/(total time). Lowest average speed is the car that covered the	C

least distance

23. As all the cars are changing direction, there must be a net force to change the direction of their velocity vectors — D

24. $F = mv^2/r$; $v^2 = rF/m$, if r decreases, v will decrease with the same applied force. Also, $v = 2\pi r f$ so $4\pi^2 r^2 f = rF/m$, or $f = F/(4\pi^2 rm)$ and as r decreases, f increases. — D

25. f = 4 rev/sec. $a = v^2/r$ and $v = 2\pi rf$ — D

26. $F = mv^2/r$ — D

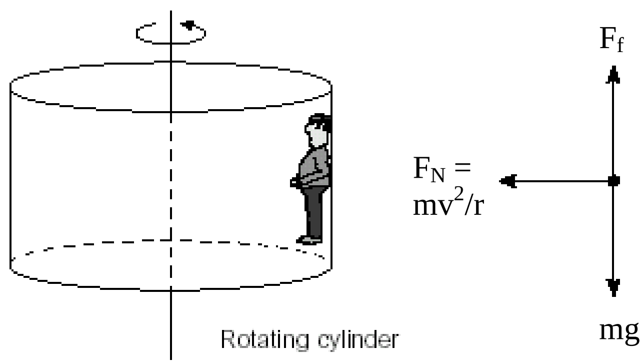
27. There is a force acting downward (gravity) and a centripetal force acting toward the center of the circle (up and to the right). Adding these vectors cannot produce resultants in the directions of B, C, D or E. — A

28. $\Sigma F = ma$; $mg + F_T = mv^2/r$ giving $F_T = mv^2/r - mg$ — B

29. At the top of the circle, $\Sigma F = F_T + mg = mv^2/R$, giving $F_T = mv^2/R - mg$. At the bottom of the circle, $\Sigma F = F_T - mg = mv^2/R$, giving $F_T = mv^2/R + mg$ The difference is $(mv^2/R + mg) - (mv^2/R - mg)$ — B

30. At the bottom of the swing, $\Sigma F = F_T - mg = ma_c$; since the tension is 1.5 times the weight of the object we can write $1.5mg - mg = ma_c$, giving $0.5mg = ma_c$ — B

31. — C



$F_f = mg$ to balance

$\mu F_N = \mu mv^2/r = mg$, where $v = 2\pi rf$ which gives $\mu = g/(4\pi^2 rf^2)$

Be careful! f is given in rev/min (45 rev/min = 0.75 rev/sec) and 8.0 m is the ride's diameter