Chapter 20
Answers and Explanations to Practice SAT Physics Subject Test 1

Answers and Explanations

Question	Answer	Explanation
1	E	Kinetic energy is a scalar, equal to one-half an object's mass times the square of its speed. Like potential energy and work, kinetic energy does not have a direction associated with it.
2	C	Newton's second law is $F_{net} = ma$, so if we know F_{net} and m, we can calculate the acceleration, a.
3	D	Impulse is equal to force multiplied by time, so its units are N-s. Because 1 N = 1 kg-m/s^2, we see that 1 N-s = 1 kg-m/s, which we immediately notice is the same as the units of mass (kg) times those of velocity (m/s), and mv is linear momentum choice (D). You may also have remembered the impulse–momentum theorem, which says that the impulse delivered to an object is equal to the resulting change in its linear momentum. Since impulse gives the change in linear momentum, it must be true that impulse can be expressed in the same units as linear momentum.
4	C	If an object's speed is changing, it must be moving, so its displacement is changing. Since velocity, v, is speed plus direction, a change in speed automatically means a change in velocity. Now, since the velocity is changing, the linear momentum, p, must be changing also, since p = mv. Finally, because kinetic energy is equal to $\frac{m}{2}$ times the square of the speed, a changing speed implies a changing kinetic energy. The answer must be (C). An object undergoing a change in speed may certainly be subject to a constant acceleration (gravitational acceleration, for example).
5	A	Momentum is mass times velocity. Since the mass of the object is just a positive constant, the graph of momentum should have the same shape as the graph of the velocity.
6	D	If the velocity vs. time graph has a corner, then the acceleration vs. time graph will be discontinuous (have a jump). As shown in the diagram, the first part of the velocity vs. time graph is a straight line with a positive slope. Thus, the corresponding acceleration graph should be a horizontal line above the axis. Next on the velocity vs. time graph there is a curvy part, decreasing but concave up (like the left half of a cup). The slope of that is negative to begin with and then becomes less negative as we approach the center of the cup. Thus a straight line on the acceleration vs. time graph–negative but getting less negative.

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7	B	Kinetic energy is proportional to v^2. Since the first part of the v versus t graph is a straight line, it must have the form $v = at$ for some constant, a. Squaring this gives us something proportional to t^2, the graph of which is parabolic. This eliminates choices (A) and (D). Next, since v drops to 0 in the original graph, the kinetic energy must also drop to 0, so now choice (E) is eliminated. Finally, we can eliminate the graph in (C), because if it were correct, it would mean that the object had a constant kinetic energy for the latter part of its motion (since the graph is flat); but the original graph shows us that v is never constant.
8	E	Since the given graph of v versus t is always above the t axis, that means v is never negative. From this we can conclude that the object never changes direction (because the velocity would change from positive to negative if this were true). If the object is always traveling in the same direction, its distance from the starting point must always increase. This behavior is only illustrated by the graph in (E).
9	B	The red shift of light refers to the increase in the wavelength (or, equivalently, the decrease in the frequency) of light from a distant source when it's measured here. This change in wavelength (and frequency) is the Doppler effect and implies that the source and detector are moving away from each other. This provides evidence for the expansion of the Universe.
10	E	Stars are huge nuclear-fusion reactors. When nuclei fuse, the mass of the product nucleus is less than the combined masses of the original nuclei. The "missing" mass has become energy, which is radiated away. Einstein's famous mass-energy equivalence equation, $E = mc^2$, can be used to calculate the amount of energy resulting from a fusion reaction.
11	B	Refraction, the change in the direction of a wave when it enters a new medium, is caused by the change in the speed of the wave as it travels within the new medium.
12	C	Only a transverse wave, defined to be a wave in which the oscillation is perpendicular to the direction of wave propagation, can be polarized. Since sound waves are longitudinal, they cannot be polarized.
13	B	The gravitational force on an object of mass m can be expressed either by mg or by $\frac{GMm}{r^2}$. Setting mg equal to $\frac{GMm}{r^2}$, we get $g = \frac{GM}{R^2}$, which is the object's (free-fall) acceleration. Notice that the mass of the object cancels out, so whether we're asked for the acceleration of the feather or the hammer, the answer would be the same. (By the way, the experiment described in this question was actually performed by Apollo 15 astronaut David Scott on July 30, 1971. Both the feather and the hammer hit the lunar surface at the same time, verifying the fact—first stated by Galileo—that under conditions of no air resistance, all objects fall with the same acceleration, regardless of their mass.)

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14	A	Let m be the mass of a satellite orbiting the earth in a circular orbit of radius r at a constant speed of v. Since the centripetal force is provided by the gravitational force due to the earth (mass M), we can write $\frac{mv^2}{r} = \frac{GMm}{r^2}$. Solving for v gives us $v = \sqrt{\frac{GM}{r}}$. This result tells us that the mass of the satellite is irrelevant; only the mass of the earth, M, remains in the formula. Since v is inversely proportional to the square root of r, the satellite that's *closer* will have the greater speed. In this case, since Satellite #1 has the smaller orbit radius, it has the greater speed, and, since the radius of its orbit is $\frac{1}{2}$ the radius of Satellite #2's orbit, its orbit speed is greater by a factor of $\sqrt{2}$.
15	E	Using the equation $p = mv$, we can figure out that before the collision, the momentum of the left-hand block was (4 kg)(8 m/s) = 32 kg-m/s, and that of the right-hand block was zero (since it was at rest), so the total momentum before the collision was 32 kg-m/s. Since total momentum is conserved in the collision, the total momentum *after* the collision must also be 32 kg-m/s.
16	D	Using the equation $K = mv^2/2$, we can figure out that before the collision, the kinetic energy of the left-hand block was (4 kg)(8 m/s)^2/2 = 128 J and that of the right-hand block was zero (since it was at rest), giving a total kinetic energy before the collision of 128 J. Since kinetic energy is conserved in an *elastic* collision, the total kinetic energy *after* the collision must also be 128 J.
17	A	If the blocks stick together after the collision—a perfectly inelastic collision—then conservation of momentum gives us 32 kg-m/s = $(4 + m)v$, where v denotes the common speed of the blocks after the collision. If m = 12 kg, then v = 32/(4 + 12) = 32/16 = 2 m/s.
18	A	If the mass of the $+q$ charge is m, then its acceleration is $$a = \frac{F_E}{m} = \frac{kQq}{m}\frac{1}{r^2}$$ The graph in (A) best depicts an inverse-square relationship between a and r.
19	E	Since Coulomb's law is an inverse-square law (that is, F is inversely proportional to r^2), if r decreases by a factor of 2, then F increases by a factor of $2^2 = 4$.
20	A	The period is the reciprocal of the frequency: $T = 1/f = 1/(2.5 \text{ Hz}) = 0.4$ sec.
21	A	We use the equation that relates wavelength, frequency, and wave speed $$\lambda f = c \Rightarrow \lambda = \frac{c}{f} = \frac{3\times10^8 \text{ m/s}}{6\times10^{15} \text{ Hz}} = 0.5\times10^{-7} \text{ m} = 5\times10^{-8} \text{ m}$$

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22	C	When a wave enters a new medium, its frequency does not change, but its wave speed does. Since $\lambda f = v$, the change in wave speed implies a change in wavelength also.
23	C	While the cannonballs are in flight, the only force they feel is the gravitational force, so the acceleration of each cannonball is equal to *g*.
24	D	For an ideal projectile, the horizontal velocity while in flight is constant and equal to the initial horizontal velocity. In this case, the initial horizontal speed of the cannonball shot from ground level is $(\frac{1}{2} v_0)\cos\theta_0$. Now, multiplying this rate by the time of flight, *T*, gives the total horizontal distance covered.
25	B	As the cannonball falls, it accelerates downward and its speed increases; this eliminates choices (A), (C), and (D). The mass of the cannonball does not change, eliminating choice (E). The answer is (B). As the cannonball falls, its height decreases, so its gravitational potential energy decreases.
26	A	Statement (B) is false, because a solid must ***absorb*** thermal energy in order to melt. Statement (C) is false since it generally requires much more energy to break the intermolecular bonds of a liquid to change its state to vapor than to loosen the intermolecular bonds of a solid to change its state to liquid. And statements (D) and (E) are false: While a substance undergoes a phase change, its temperature remains constant. The answer must be (A).
27	E	We know that like charges repel and opposite charges attract. So, we can put Charges 1, 2, 3, and 4 into two "camps." Because Charge 1 attracts Charge 2, these charges must be in opposite camps 1 2 Next, since Charge 2 repels charge 3, Charge 3 is in the same camp as Charge 2 1 2 3 And, finally, since Charge 3 attracts Charge 4, these charges are in opposite camps, giving us 1 2 4 3 We now see that only statement (E) can be correct.
28	B	The current entering the parallel combination containing Resistors *b*, *c*, and *d* will split evenly among the resistors since all their resistances are the same. Because there are 3 resistors in the parallel combination, each resistor in this combination will get 1/3 of the current. Another way of saying that the current through Resistor *b* is 1/3 the current through Resistor *a* is to say that the current through Resistor *a* is 3 times the current through Resistor *b*.