Set of Ten Matching Questions: #95-#104

Place the letter which best matches the numbered phrase into the corresponding numbered line of your NCS answer sheet.

g	95	Newton's Second Law	a	$=\Delta(K.E.)$
i	96	Newton's Law of Universal Gravitation	b	$=h*f$
e	97	Centripetal Force in Uniform Circular Motion	c	$\Leftrightarrow \quad \Delta S \geq 0$
h	98	The Impulse-Momentum Theorem: Impulse	d	$=h/p$
a	99	The Work-Energy Theorem: Work	e	$=mv^2/r$
j	100	First Law of Thermodynamics	f	$=\lambda*f$
c	101	Second Law of Thermodynamics	g	$=\Delta(\gamma mv)/\Delta t$
f	102	Wave velocity of periodic traveling wave	h	$=F*\Delta t$
b	103	Energy of Photon	i	$=GMm/R^2$
d	104	de Broglie Wavelength of particle	j	$Q_{IN} + W_{IN} = \Delta U_{internal}$

The exam is continued on page 19 and following.....

The following 16 questions may typically require more computation than those preceding. Please place the letter for the single most nearly correct answer into the correspondingly numbered line on you r NCS answer sheet.

105 . You throw a ball vertically to a friend on a balcony 20 m above your launch point What is the minimum launch speed which guarantees that the ball will reach him?

a. 4 m/s
b. 8 m/s
c. 20 m/s
d. 40 m/s
e. None of the above is within 10% of the correct answer.

$d = \frac{1}{2}at^2 = 20 \Rightarrow t = \sqrt{\frac{2\cdot 20}{10}} = 2$ sec

Then v_0 must decrease to $v(2) = 0$ at $t = 2$:

$v(t=2) = v_0 + at = v_0 - 10\cdot 2 = 0$

$\Rightarrow v_0 = 20$ m/sec.

106. A baseball is hit with a speed of 20 m/s at an angle 30° upward, and has traveled 34.6 m horizontally when it returns to the (level) ground. If another baseball is hit at the same angle, but with an initial speed of 50 m/s, the second ball will travel, most nearly, ___________m__ before it hits the ground.

a. 35 m
b. 87.5 m
c. 138 m
d. 216m
e. 432 m
f. None of the above is within 10% of the correct answer.

2nd ball travels 2.5 times as long a time, since initial vertical speed is 2.5 times greater ... so that it takes 2.5X as long a time to reach top (where $v = 0$)
& " " " " " to fall back to ground.
& Horizontal speed is 2.5X greater.

Also Therefore D' = DISTANCE $= v_x' \cdot t'$ is $(2.5)(2.5) \times (v_x t)$

$= (6.25)(34.6\text{ m}) = \boxed{216.25\text{ m.}}$

$\boxed{\text{OR}}$ $\vec{v}_0 = 20$ m/sec at $30° = (v_{x_0} = 17.3$ m/s ; $v_{y_0} = 10$ m/s$)$

& $v_{y_0} - g t_{top} = 0$ at top $\Rightarrow t_{top} = 10/10 = 1$ sec. & $D = 2 \cdot t_{top} \cdot v_{x0}$

$D = 34.6 = 2(17.3)(1.)$

For $\vec{v}_0' = (v_{x_0}' = 43.25;\ v_{y_0}' = 25)$, $t_{top}' = 2.5$

& $D' = (2.5)(2)(43.25) = \boxed{216.2\text{ m}}$

107. A 47-kg crate is being pushed across a horizontal floor by a horizontal applied force of 240 N. If the coefficient of sliding friction is 0.5, and the speed is 2m/s at time t = 0, how far does the crate move in the next ten seconds, most nearly ? (Use the approximate value, $g = 10\ m/s^2$ in your calculation.)

a. 20 m
b. 100 m
c. 120 m
d. 600 m
e. 620 m

$F_f = \mu \cdot |Mg| = (0.5)(47)(10) = 235\ N$

$F_{NET} = F_{APP} + F_f = 240 - 235 = 5\ N$

$a = \frac{F_{NET}}{m} = \frac{5}{47} = 0.11\ m/s^2$

$x(t) = x_0 + v_0 t + \frac{a}{2} t^2 = 0 + 2 \cdot 10 + \frac{0.11}{2}(10)^2$

$= 20 + \frac{11}{2} = 25.5\ m$ (a)

108. Suppose that a satellite is orbiting the earth at a constant distance of 3 earth radii from its center. What is its speed? (Take the radius of the earth to be 6.4×10^6 m)

a. 2.9×10^3 m/s
b. 4.5×10^3 m/s
c. 2.9×10^4 m/s
d. 4.5×10^4 m/s
e. 2.9×10^5 m/s
f 4.5×10^5 m/s
g. None of the above is within 10% of the correct answer.

at $r = 3R_E$, $\frac{F_G}{m} = a = \frac{GM_E}{9R_E^2} = \frac{1}{9} g = \frac{9.8}{9} = 1.09 \frac{m}{sec^2}$

Also $a = v^2/r$ for uniform circular motion:

$\frac{v^2}{3R_E} = 1.09 \frac{m}{sec^2} \Rightarrow \sqrt{v^2} = \sqrt{3 \cdot (6.4 \times 10^6)(1.09)} = v = 4.6 \times 10^3 \frac{m}{sec}$

109. A 160-kg satellite orbits a distant planet at a fixed distance of 4000 km and a period of 280 min. From the radius and period, you calculate the satellite's acceleration to be 0.56 m/s^2. What is the gravitational force on the satellite, most nearly ?

a. 10^2 N
b. 10^3 N
c. 10^4 N
d. 10^5 N
e. 10^6 N
f. 10^7 N
g. None of the above is within 30% of the correct answer

$F_G = ma = (160)(0.56) = 89.6\ N \approx 10^2$ MOST NEARLY

110. A boxcar traveling at 5 m/s approaches a string of four identical boxcars sitting stationary on the track. The moving boxcar collides and links with the stationary cars, and the five move off together along the track. What is the final speed of the four cars immediately after the collision, most nearly ? (You may take the mass of each boxcar to be 20,000 kg.)

a. 5 m/s
b. 4 m/s
c. 3 m/s
d. 2 m/s
e. 1 m/s
f. None of the above is within 10%.

$P_{TOT} = P^{TOT}_{INIT.} = M \cdot 5 + 4M \cdot 0 = P^{TOT}_{FIN}$

$= 5M \cdot V_f$

$V_F = \frac{5M}{5M} = 1.0$ m/sec

111. A block weighing 20 N is lifted straight upward from rest by applying a steady force of 32 N. If the block is lifted 5 m, what is the block's final speed?

a. 5 m/s
b. 4 m/s
c. 3 m/s
d. 2m/s
e 1m/s
f. None of the above is within 10%.

$F \cdot \Delta x = W = \Delta(KE)$

$32 \cdot 5 = 160\ J = \frac{1}{2} M v_f^2$, where $M = \frac{20 N}{g} = 2 kg.$

$v_f = \sqrt{v_f^2} = \sqrt{\frac{2 \cdot 160}{2}} = 12.6$ m/sec : (f)

112. A cylindrical space habitat with a 100,000-m radius is rotating so that a person standing on the inside feels a centripetal acceleration equal to g = 10 m/sec^2. What is the tangential speed of a point just inside the cylinder?

a. 10 m/s
b. 10^2 m/s
c. 10^3 m/s
d. 10^4 m/s
e. 10^5 m/s
f. 10^6 m/s
g. None of the above is within 10%.

$\frac{v^2}{R} = g \Rightarrow v = \sqrt{v^2} = \sqrt{10^5 \cdot 10} = 10^3$ m/sec

113. If the speed, v, of a particle of rest mass m increases so that v/c increases from $(1-10^{-5})$ to $(1-10^{-7})$. By what factor does its total energy increase, most nearly?

a. $(1+10^{-7})$
b. $(1+10^{-6})$
c. $(1+10^{-5})$
d. 4.67
e. 10
f. 100
g. None of the above is within 10%.

$$\frac{E_i^{TOT}}{E_f^{TOT}} = \frac{\gamma_i \cancel{m}\cancel{c}^2}{\gamma_f \cancel{m}\cancel{c}^2} = \frac{\sqrt{1-(v_f/c)^2}}{\sqrt{1-(v_i/c)^2}} \approx \frac{\sqrt{2(1-v_f/c)}}{\sqrt{2(1-v_i/c)}}$$

$$= \frac{\sqrt{10^{-7}}}{\sqrt{10^{-5}}} = \sqrt{10^{-2}} = 1/10$$

i.e. E^{TOT} increases by 10x

114. A hypothetical balloon filled with an ideal gas has a volume of 10^3 liters at 27°C under one atmosphere of pressure. At what temperature, most nearly, will its volume be 330 liters under one atmosphere of pressure?

300K = T_i

a. -273°C
b. -223°C
c. -173°C
d. -123°C
e. -73°C

$$\frac{\cancel{P_i} V_i}{\cancel{P_f} V_f} = \frac{\cancel{k} T_i}{\cancel{k} T_f} = \frac{10^3}{330} = \frac{300\,K}{T_f}$$

$$T_f = \frac{(300)(330)}{10^3} \approx 100\,K$$

8 $(T_f)_{centi} = 100 - 273 = -173°C$

115. If 200 g of water at 100°C and 300 g of ice at 0°C are mixed in a completely insulated container, what is the final equilibrium temperature, most nearly ? Recall that the latent heat of fusion of ice is 80 cal/g.

a. -10°C
b. 0°C
c. 10°C
d. 20°C
e 30 °C
e. None of the above is within 10% of the correct answer.

$200g(1)[T_f - \overset{100}{T_i}] + 300g(80) + 300(T_f - \overset{0°}{T_i}) = 0.$

$500T_f = +2\times10^4 - 2.4\times10^4 = -0.4\times10^4 \Rightarrow T_f = \frac{-4000}{500} = -8°C$

This is IMPOSSIBLE as T_f must be in range $0°C \leq T_f \leq 100°C$!

THEN only $\frac{250}{80}$ gm of ice melts & final state is 50gm ice + 450gm water all at 0°C (b)

116. .A heat engine takes in 600 J of energy at 1000 K and exhausts 400 J at 300 K. What is the theoretical maximum efficiency (i.e., the Carnot efficiency) for this engine, and what is its actual efficiency, respectively ?

$\eta_{Carnot} \Rightarrow 1 - \frac{300}{1000} = 0.7 = 70\%$

$\eta_{Actual} = \frac{200}{600} = 33\%$

a. 30% and 33%, respectively.
b. 30% and 67%, respectively.
c. 33% and 33%, respectively.
d 33% and 67%, respectively
e ~~d.~~ 67% and 30%, respectively.
f ← 67% and 70%, respectively.
(g) ← 70% and 33%, respectively
h ← 70% and 67%, respectively
i ← In none of the above are both answers correct within 10% of the value

117. An engine takes in 12,600 cal of heat and exhausts 4200 cal of heat each minute it is running. How much work does the engine do each minute? (Recall that 4.2 J is equivalent to 1 cal.)

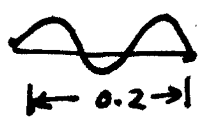
   a. 1000 cal.
   b. 2000 cal.
   c. 3000 cal.
   d. 4200 cal.
   e. 8400 cal.
   f. 12,400 cal.
   g. None of the above is within 10% of the correct answer.

$W_{out} = Q_{IN} - Q_{out}$

$W = 12{,}600 - 4200 = \underline{8400}$ cal

118. The transverse wave speed along a string of length 0.2m fixed at both ends is 100 m/s. What is the frequency of the third standing wave on this string?

   a. 750 Hz
   b. 625 Hz
   c. 500 Hz
   d. 375 Hz
   e. 250 Hz
   EC → f ~~e.~~ None of the above is correct within 10%.



3rd standing wave has

$3 \frac{\lambda_3}{2} = d = 0.2$

$\lambda_3 = \frac{(2)(0.2)}{3} = 0.133$ m

& $v = \lambda_3 \cdot f_3 \Rightarrow f_3 = \frac{100\ m/s}{0.133\ m} = 750$ Hz

119. The energy levels of the Hydrogen atom are correctly given by the formula of the Bohr model; as follows: $E_n = -13.6/n^2$, where n = 1, 2, 3,…gives the lowest orbits. (The energy units are electron Volts: $1 eV = 1.6 X 10^{-19}$ J.) Calculate the energy emitted when an electron jumps from the third Bohr orbit to the second orbit.

a 13.6 eV
b. 12.1 eV
c. 3.4 eV
d. 1.9 eV
e None of the above is correct within 10%.

$\Delta E = -13.6\left(\frac{1}{(3)^2} - \frac{1}{(2)^2}\right) = 1.89 eV$

120. The radio emission from WTOP has a carrier frequency of 1500 kilo-Hz. What is the energy of one photon in the emission, most nearly? (Planck's constant is $h = 6.63 X 10^{-34}$ J·s.)

a. 10^{-27} J
b. 10^{-28} J
c. $5 X 10^{-29}$ J
d. $5 X 10^{-30}$ J
e. None of the above is correct within 10%.

$E = hf = (6.63 \times 10^{-34} J\cdot s)\left(\frac{1500 \times 10^{6}}{s}\right)$

$= 9.94 \times 10^{-34+6} \simeq 10^{-27} J$

End of exam