EXAM 1 **PHYS 103** **VERSION A** **FALL 2004**

NAME: ____

As a student at NJIT I ____________________________________, will conduct myself in a professional manner and will comply with the provisions of the NJIT Academic Honor Code. I also understand that I must subscribe to the following pledge on major work submitted for credit as described in the NJIT Academic Honor Code:
On my honor, I pledge that I have not violated the provisions of the NJIT Academic Honor Code.
Signature_________________

The exam is closed book and closed notes. Choose the answer that is closest to the given answer.

$x = A\cos(\omega t)$ $v = -\omega A\sin(\omega t)$ $\omega = 2\pi f = \frac{2\pi}{T}$ $F = kx$ period: $T_{spring} = 2\pi\sqrt{\frac{m}{k}}$; $T_{pend} = 2\pi\sqrt{\frac{L}{g}}$

$\omega = \sqrt{\frac{k}{m}}$ $f = \frac{1}{T}$ $v_{max} = A\omega$ $E = ½ mv^2 + ½ kx^2$; $E = ½ kA^2$; $E = ½ m(v_m)^2$

$v = \lambda f$; $f = 1/T$ linear mass $\mu = \frac{m}{L}$; $v = \sqrt{\frac{F}{\mu}}$ sound: $v = 343$ m/s $I_0 = 10^{-12}$ W/m^2

$\text{sound}: I = \frac{P}{A} = \frac{P}{4\pi r^2}$ $\beta = 10\text{dB}\log\frac{I}{I_0}$ $f = f_0\frac{343\text{m/s} \pm v_D}{343\text{m/s} \pm v_S}$

$b_2 - b_1 = 10\text{dB}\log(I_2/I_1)$ standing waves: n = 1, 2, 3 .., or n = 1, 3, 5, … 1m = 100 cm 1 kg = 1000 g

$\text{string}: \lambda = \frac{2L}{n}$ $f = \frac{v}{2L}n$ $\text{open}: \lambda = \frac{2L}{n}$ $f = \frac{v}{2L}n$ $\text{closed}: \lambda = \frac{4L}{n}$ $f = \frac{v}{4L}n$

1E 2A 3C 4D 5D 6D 7B 8E 9A 10B 11B 12B 13 B 14 E 15 C 16A 17A 18C 19A

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1. A vertical spring stretches 6 cm when a 18-kg block is hung from its end. What is the spring constant of this spring?
A) 2 N/m
B) 196 N/m
C) 690 N/m
D) 1470 N/m
E) 2940 N/m

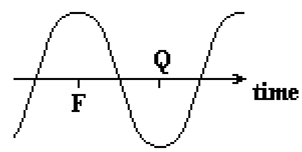
2. A 3-kg block, attached to a spring, executes simple harmonic motion according to x = 2 cos (30 rad/s·t), where x is in meters and t is in seconds. The period of oscillation of the spring is:
A) 0.2 s
B) 0.4 s
C) 0.6 s
D) 0.8 s
E) 1.8 s

3. A 3-kg block, attached to a spring, executes simple harmonic motion according to x = 0.8 cos (35 rad/s·t), where x is in meters and t is in seconds. The position x of the spring at t = 1.4 sec is:
A) 0.10 m
B) 0.15 m

C) 0.24 m
D) 1.60 m
E) 2.2 0 m

4. A 0.25 - kg block oscillates on the end of the spring with a spring constant of 1000 N/m. If the oscillation is started by elongating the spring 0.12 m, what is the maximum speed of the block?
A) 1.5 m/s
B) 3.5 m/s
C) 5.5 m/s
D) 7.6 m/s
E) 9.5 m/s

5. In the diagram below, the interval FQ represents;
A) wavelength/2
B) wavelength
C) 2 x amplitude
D) period/2
E) period



6. A sinusoidal wave of length 1.2 m travels along a string. If the period of the wave is 0.48 s. What is the wave speed?
A) 0.4 m/s
B) 0.9 m/s
C) 1.6 m/s
D) 2.5 m/s
E) 3.1 m/s

7. Which of the following is a false statement?
A) Sound waves are longitudinal pressure waves,
B) Sound can travel through a vacuum
C) Light travels very much faster than sound
D) The transverse waves on a string are different from sound waves
E) none of the above

8. The intensity at a distance of 6.0 m from a source that is radiating equally in all directions is 9.85 x 10^{-9} W/ m^2 . What is the intensity level in dB?
A) 17.0 dB
B) 20.0 dB
C) 26.0 dB
D) 32.0 dB
E) 40.0 dB

9. A barking dog delivers about 2 x10^{-3} W of power, which is assumed to be uniformly distributed in all directions. What is the intensity level at a distance 5.0 m from the dog?
A) 6.4x10^{-6} W/m^2
B) 4.5x10^{-4} W/m^2
C) 8.0x10^{-4} W/m^2
D) 2.2x10^{-3} W/m^2
E) 9.3x10^{-2} W/m^2

10. The intensity of a certain sound wave is 5x10^{-7} W/m^2. If its intensity is raised by 30 decibels, what is the new intensity in W/m^2?
A) 6x10^{-5} W/m^2

B) $5x10^{-4}$ W/m^2
C) $8x10^{-4}$ W/m^2
D) $2x10^{-3}$ W/m^2
E) $3x10^{-2}$ W/m^2

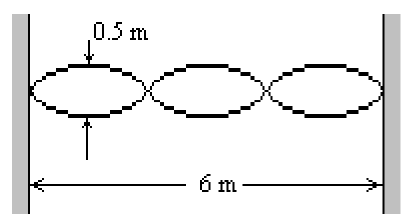
11. A stationary source emits sound with a frequency of 1250 Hz. If the speed of the sound is 343 m/s, what frequency is heard by an observer approaching the source with a speed of 25 m/s?
A) 1550 Hz
B) 1341 Hz
C) 1110 Hz
D) 890 Hz
E) 20 Hz

12. The fundamental frequency of a standing wave on a string of linear mass 0.004 kg/m and length 0.6 m when it is subjected to tension of 50.0 N is closest to:

A) 132 Hz
B) 93 Hz
C) 152 Hz
D) 365 Hz
E) none of above

13. A string of linear mass 0.0015 kg/m is under a tension of 40 N. What should its length be if the frequency of the second harmonic is 440 Hz?
A) 0.26 m
B) 0.37 m
C) 0.41 m
D) 0.85 m
E) 1.5 m

14. A standing wave pattern is established in a string as shown. What is the wavelength of the standing wave?
A) 0.25 m
B) 0.5 m
C) 1.0 m
D) 2.0 m
E) 4.0 m



15. A laboratory vacuum pump can reduce the pressure to$1x10^{-7}$ Pa. If the volume of the chamber is 0.5 m^3 and the temperature is 27^0C, how many molecules are left inside the chamber? (R = 8.31 J/mol·K).
A) $1.2x10^{13}$
B) $2.4x10^{13}$
C) $3.0x10^{12}$
D) $0.5x10^{11}$
E) $4.0x10^{10}$

16. An ideal gas occupies 0.6 m^3 when its temperature is 20^0 and its pressure is 1.5 atm. Its temperature is now raised to 100^0C and its volume increased to 1.2 m^3 . The new pressure is:
A) 0.1 atm
B) 0.3 atm
C) 0.52 atm

D) 0.95 atm
E) 1.40 atm

17. An automobile tire is pumped up to a absolute pressure of 2.2 atm when the temperature is 27^0C. What is its absolute pressure after the car has been running on a hot day so that the tire temperature is 47^0C? Assume constant volume.
A) 1.25 atm
B) 2.35 atm
C) 2.58 atm
D) 3.61 atm
E) 4.5 atm

18. What is the temperature of 3 moles of gas at a pressure of 250 kPa held in a volume of $15x10^{-3}$ m^3?
A) 50 K
B) 100 K
C) 150 K
D) 200 K
E) 300 K

19. How many grams of ice at temperature 0^0C has to be added to a 150 g of water to decrease the temperature of water from 45^0C to 25^0C. (latent heat of water is 335000 J/kg; specific heat of water is 4186 J/kg^{0}C)
A) 29 g
B) 36 g
C) 49 g
D) 73 g
E) 91 g

0.15kg*4186*(45-25)=335000*M+4186*(25-0)*M
M=0.15*4186*20/(335000+4186*25)=0.029 kg = 29 g

PROBLEM 1

STEP 1: SPRING PROBLEM → USE HOOKE'S LAW → $F = kx$

STEP 2: x IS GIVEN AS 6cm → CONVERT TO METERS → .06m

STEP 3: TO CALCULATE F → F = (mass)(acceleration due to gravity) SO...

$F = mg \rightarrow F = (18\,\text{kg})(9.8\,\text{m/s}^2) = 176.4\,\text{N}$

STEP 4: NEED TO SOLVE FOR THE SPRING CONSTANT; $\boxed{k}$ SO...

$F = kx \rightarrow \frac{F}{x} = \frac{k\cancel{x}}{\cancel{x}} \rightarrow \frac{F}{x} = k \rightarrow \boxed{k = F/x}$

STEP 5: SOLVE FOR k; $k = F/x \rightarrow k = \frac{176.4\,\text{N}}{.06\,\text{m}} \rightarrow \boxed{k = 2940\,\text{N/m}}$

PROBLEM 2

STEP 1: SPRING PROBLEM → NEED TO SOLVE FOR PERIOD → USE $\omega = 2\pi f = \boxed{\frac{2\pi}{T}}$

STEP 2: ω = angular frequency → THIS GIVEN! → $x = 2\cos(30\,\text{rad/s} * t)$ THIS IS ω!

STEP 3: SO IF $\omega = 30\,\text{rad/s}$; NOW WE CAN SOLVE FOR PERIOD; T USING $\boxed{\omega = \frac{2\pi}{T}}$

STEP 4: $\omega = \frac{2\pi}{T} \rightarrow 30 = \frac{2\pi}{T} \rightarrow T = \frac{2\pi}{30} \rightarrow \boxed{T = .2\,\text{s}}$ (ROUNDED)

PROBLEM 3

STEP 1: SPRING PROBLEM → USE HOOKE'S LAW → $F = kx$

STEP 2: FIRST THING IS THAT SINCE THE WEIGHT OF BLOCK IS GIVEN; 3-kg ... WE CAN USE $F = mg$ TO CALCULATE F; $F = (3\,\text{kg})(9.8\,\text{m/s}^2) \rightarrow F = 29.4\,\text{N}$

STEP 3: BUT SINCE THIS PROBLEM GIVES YOU → $x = 0.8\cos(35\,\text{rad/s} * t)$; WHERE x IS IN RADIANS AND t IS IN SECONDS → JUST PLUG IN TO FIND x

STEP 4: PLUG IN t → $x = 0.8\cos(35\,\text{rad/s} * t) \rightarrow x = 0.8\cos(35\,\text{rad/s} * (1.4\,\text{s}))$ ← t IS GIVEN!

$\boxed{x = .24\,\text{m}}$

PAGE

PROBLEM 4

STEP 1: FINDING THE SPEED OF THE BLOCK CAN BE ACHIEVED USING THE FORMULA

$\rightarrow E = \frac{1}{2}mv^2 + \frac{1}{2}kx^2$

STEP 2: TO CALCULAT E; WE SET THE VALUE FOR v AS $v=0$ AND SOLVE FOR E...

STEP 3:

① $E = \frac{1}{2}m(0)^2 + \frac{1}{2}kx^2$

② $E = \frac{1}{2}kx^2 \rightarrow E = \frac{1}{2}(1000)(.12)^2$

③ $E = 7.2$

STEP 4: SINCE THE E; SHOULD NEVER CHANGE (ENERGY OF A SYSTEM), THEN WE PLUG IN [0] FOR THE VALUE OF x... THIS IS BECAUSE v_{max} WOULD BE WHERE x IS EQUAL TO ZERO...

① $E = \frac{1}{2}mv^2 + \frac{1}{2}kx^2$

② $7.2 = \frac{1}{2}(.25)v^2 + \frac{1}{2}(1000)(0)^2$

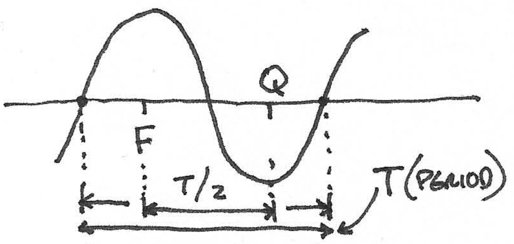
③ $7.2 = \frac{1}{2}(.25)v^2 \rightarrow 7.2 = .125v^2 \rightarrow \frac{7.2}{.125} = \frac{\cancel{.125}v^2}{\cancel{.125}}$

④ $v^2 = \frac{7.2}{.125} \rightarrow v^2 = 57.6$

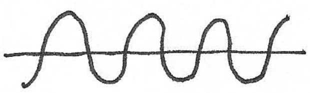
⑤ $\sqrt{v^2} = \sqrt{57.6}$

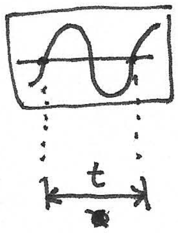
⑥ $\boxed{v \approx 7.6 \text{ m/s}}$

PROBLEM 5



① • PERIOD IS WHERE THE PATTERN REPEATS ITSELF IN A WAVE...

② • SO FOR 

③ • IT WOULD BE 

AND THIS TIME LAPSE

④ SO FQ IS HALF OF THE PERIOD FOR THIS WAVE

⑤ ANSWER IS $\boxed{T/2}$

PROBLEM 6

STEP 1: FINDING THE WAVE SPEED ON A STRING CAN BE ACHIEVED THROUGH $v = \lambda f$

v = speed ; λ = wavelength; f = frequency ...

STEP 2: λ IS GIVEN TO YOU AS 1.2m ; f IS NOT BUT SINCE T IS GIVEN TO YOU AS $\boxed{0.48s}$ WE CAN USE $f = 1/T$ TO SOLVE FOR f

STEP 3: $f = 1/T \rightarrow f = 1/0.48 \rightarrow \boxed{f = 2.08}$

STEP 4: NOW PLUG IN AND SOLVE

① $v = \lambda f \rightarrow v = (1.2m)(2.08)$

② $\boxed{v = 2.5\ m/s}$

PROBLEM 7

- SOUNDS CANNOT TRAVEL THROUGH A VACUUM BECAUSE THEY RELY ON VIBRATIONS THROUGH VARIOUS MEDIUMS AND THERE IS NO PHYSICAL MATERIAL IN A VACCUUM.

PROBLEM 8

STEP 1: TO CALCULATE THE INTENSITY OF A SOUND WE CAN USE THE FORMULA THAT $\beta = 10dB \log \frac{I}{I_0}$

STEP 2: SO WE PLUG IN FOR I WHICH IS; $I = 9.85 \times 10^{-9}\ W/m^2$ AND FOR I_0 WHICH IS A CONSTANT WE USE $I_0 = 10^{-12}\ W/m^2$

REMEMBER THAT dB IS JUST TO DESIGNATE UNITS IT IS NOT A VARIABLE

① $\beta = \underline{10dB} \log\left(\frac{9.85 \times 10^{-9}}{10^{-12}}\right)$

② $\beta = 40dB$

PROBLEM 9

STEP 1: TO CALCULATE THE INTENSITY AT A DISTANCE WE CAN USE THE GIVEN EQUATION AS $I = \frac{P}{4\pi r^2}$; I = intensity ; r = distance from center

STEP 2: $\boxed{P}$ IS GIVEN AS $P = 2 \times 10^{-3} W$; $\boxed{r}$ IS GIVEN AS $r = 5.0m$

So WE PLUG IN ... FOR $I = \frac{P}{4\pi r^2}$

① $I = \frac{(2 \times 10^{-3})}{4\pi(5)^2} \rightarrow \boxed{I = 6.4 \times 10^{-6}}$

PROBLEM 10

STEP 1: TO FIND THE INTENSITY OF A SOUND WAVE AFTER IT HAS BEEN RAISED YOU USE $\beta = 10dB \log \frac{I}{I_o}$; $I = 5\times10^{-7}$ ... TO CALCULATE THE dB

STEP 2: ① $\beta = 10dB \log \frac{5\times10^{-7}}{10^{-12}}$ CONSTANT!

② $\beta =$ 57dB

STEP 3: NOW ADD 30dB TO THE 57dB : 30dB + 57dB = 87dB

STEP 4: REPLUG THE NEW dB TO CALCULATE NEW INTENSITY!

① $87dB = 10dB \log\left[\frac{I}{10^{-12}}\right]$

② $\frac{87dB}{10dB} = \frac{\cancel{10dB} \log\left[\frac{I}{10^{-12}}\right]}{\cancel{10dB}}$

③ $8.7dB = \log\left(\frac{I}{10^{-12}}\right)$

④ $10^{8.7} = \cancel{10^{\log}}^{\left(\frac{I}{10^{-12}}\right)}$

⑤ $10^{8.7} = \frac{I}{10^{-12}}$

⑥ $(10^{8.7})(10^{-12}) = I$

⑦ $\boxed{I_{NOW} = 5\times10^{-4}\ W/m^2}$

PROBLEM 11

STEP 1: TO CALCULATE THE FREQUENCY HEARD BY OBSERVER USE; $f = f_o \frac{343 m/s \pm V_D}{343 m/s \pm V_S}$

STEP 2: PLUG IN f_o WHICH IS GIVEN AS 1250Hz ; V_D IS GIVEN AS 25 m/s ; AND AS FOR V_S IT IS 0 m/s BECAUSE THE ... SOURCE OBJECT IS NOT MOVING.

STEP 3: ① $f = (1250) \frac{343 m/s + (25)}{343 m/s + (0)}$

② $\boxed{f = 1341\ Hz}$

PROBLEM 12:

STEP 1: TO FIND THE FUNDAMENTAL FREQUENCY OF A STANDING WAVE ON A STRING; YOU CAN USE $f = \frac{v}{2L} n$; f = fundamental frequency ; v = speed; L = length ; n = nodes...

STEP 2: GIVEN TO YOU IS THE VALUE FOR linear mass (μ) = .004 kg/m ; length (L) = .6m ; AND tension (F) = 50.0N... SO SINCE WE NEED TO FIND v (speed) WE NEED TO USE ANOTHER FORMULA $v = \sqrt{\frac{F}{\mu}}$ FIRST

STEP 3: SOLVE FOR v

① $v = \sqrt{\frac{F}{\mu}} \rightarrow v = \sqrt{\frac{50.0}{.6}}$

② $v = 112$

STEP 4: NOW WE PLUG INTO FIRST EQUATION TO SOLVE FOR f (FUNDAMENTAL FREQ.)

① $f = \frac{v}{2L}(n)^* \rightarrow f = \frac{(112)}{2(.6)}(1) \leftarrow$ *WE USE 1 FOR n; SINCE THIS IS A STANDING WAVE THAT IS CLOSED

② $\boxed{f = 93 Hz}$

PROBLEM 13:

STEP 1: TO FIND THE LENGTH OF A STRING BASED ON THE GIVEN DATA WE CAN USE THE FORMULA $f = \frac{v}{2L} n$ AGAIN

STEP 2: GIVEN TO YOU IS THE VALUE FOR linear mass (μ) = .0015 kg/m ; tension (40N) ; n = 2 (second harmonic) ; and f (fundamental frequency) = 440 Hz

STEP 3: SINCE WE ARE MISSING v (speed) ; WE USE $v = \sqrt{\frac{F}{\mu}}$

① $v = \sqrt{\frac{F}{\mu}} \rightarrow v = \sqrt{\frac{40}{.0015}}$

② $v = 163.3$

STEP 4: NOW PLUG IN FOR $f = \frac{v}{2L} n$

① $440 Hz = \frac{163.3}{2L}(2)$

② $440 * 2 * L = 163.3 * 2$

③ $\frac{440 * \cancel{2} * L}{\cancel{2}} = \frac{163.3 * \cancel{2}}{\cancel{2}}$

④ $440 L = 163.3$

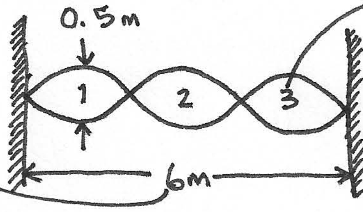
⑤ $L = \frac{163.3}{440} \rightarrow \boxed{L = .37 m}$

PROBLEM 14

STEP 1: TO FIND THE WAVELENGTH OF THE STANDING WAVE PATTERN SHOWN WE CAN USE THE FORMULA; $\lambda = \frac{2L}{n}$

STEP 2: YOU ARE GIVEN:

$L = 6$



THERE ARE 3 ANTINODES HERE!

$n = 3$

STEP 3: PLUG IN FOR $\lambda = \frac{2L}{n}$

① $\lambda = \frac{2(6)}{3}$

② $\boxed{\lambda = 4m}$

PROBLEM 15

STEP 1: TO FIND HOW MANY MOLECULES ARE LEFT INSIDE THE CHAMBER WE CAN USE: $PV = nRT$; P = pressure ; V = volume ; n = amount ; $R = 8.313\ J/mol \cdot K$; T = temperature (KELVINS)

STEP 2: WE ARE GIVEN PRESSURE (P) AS $1 \times 10^{-7} Pa$; VOLUME (V) AS $0.5 m^3$; TEMPERATURE (T) AS $27°C$; R IS CONSTANT (8.313)

STEP 3: FIRST WE CONVERT THE TEMPERATURE GIVEN TO KELVIN BY USING

$T_K = 273 + T_C$ ① $T_K = 273 + 27 \rightarrow$ ② $T_K = 300$

STEP 4: NOW WE PLUG IN TO FIND THE VALUE FOR n

① $PV = nRT$

② $(1 \times 10^{-7})(.5) = n\,(8.31)(300)$

③ $n = 2 \times 10^{-11}$

STEP 5: NOW MULTIPLY $\underline{n}$: (2×10^{-11}) BY n_{av} (AVOGADRO'S NUMBER) $= 6.02 \times 10^{23}$

$(2 \times 10^{-11}) * (6.02 \times 10^{23}) = \boxed{1.2 \times 10^{13}}$

PROBLEM 16:

STEP 1: TO FIND THE NEW PRESSURE WE CAN USE THE FOLLOWING FORMULA $\frac{P_1 V_1}{T_1} = \frac{P_2 V_2}{T_2}$ P = pressure ; V = volume ; T = temperature

STEP 2: YOU ARE GIVEN $V_1 = 0.6\,m^3$; $V_2 = 1.2\,m^3$; $T_1 = 293K$; $T_2 = 373K$; $P_1 = 1.5\,atm$ (T_1 : T_2 WERE CONVERTED TO KELVINS)

STEP 3: P_1 NEEDS TO BE CONVERTED TO PASCALS (Pa) SO SINCE 1 ATM = 1.013×10^5 Pa

WE DO $1.5 \times 1.013 \times 10^5\,Pa \rightarrow P_1 = 1.5195 \times 10^5$

STEP 4: ① $\frac{P_1 V_1}{T_1} = \frac{P_2 V_2}{T_2} \rightarrow \frac{(1.5195 \times 10^5)(.6)}{293} = \frac{P_2 (1.2)}{373}$

② $311.2 = \left(\frac{1.2}{373}\right) P_2$

③ $\frac{311.2}{.00322} = P_2$

④ $P_2 = 96645.96\,Pa \rightarrow$ *CONVERT TO ATM $\boxed{.95\ ATM}$

PROBLEM 17:

STEP 1: TO FIND THE NEW PRESSURE WE CAN USE $\frac{P_1}{T_1} = \frac{P_2}{T_2}$

STEP 2: ① $\frac{P_1}{T_1} = \frac{P_2}{T_2} \rightarrow \frac{(2.2)}{300K} = \frac{P_2}{320K}$

② $\boxed{P_2 = 2.35\ atm}$

PROBLEM 18:

STEP 1: WE WILL AGAIN USE PV = nRT TO FIND TEMPERATURE...

STEP 2: CONVERT 250 kPa → Pa → 250 kPa = 250,000 Pa

STEP 3: PLUG IN → PV = nRT

① $250000(.015) = 3(8.313)T$

② $\frac{250{,}000 * .015}{3 * 8.313} = T$

③ $\boxed{T = 150K}$

*PROBLEM 19

STEP 1: TO FIND THE AMOUNT OF GRAMS TO BE ADDED: WE SET UP USING TWO FORMULAS; $Q = mL$ AND $Q = mc(\Delta T)$

STEP 2: SETTING UP WE HAVE $\underbrace{mc(\Delta T)}_{\text{before}} = mL + \underbrace{mc(\Delta T)}_{\text{after}}$

BEFORE: WE HAVE ALL DATA ... AFTER: WE ARE MISSING m

STEP 3: PLUG IN

*SINCE THESE ARE EQUAL (GRAMS ADDED) WE CAN FACTOR THEM OUT

① $mc(\Delta T) = mL + mc(\Delta T)$

② $mc(\Delta T) = m[L + c(\Delta T)]$

FOR WATER CONSTANT!

(25-0)

③ $(.15\,kg)(4186)(20°C) = m[335000 + (4186 \cdot 25)]$

CONSTANT! FOR WATER...

(45-25)

④ $12558 = m(439650)$

⑤ $\frac{12558}{439650} = \frac{439650m}{439650}$

⑥ $m = .029\,kg \rightarrow \boxed{m = 29g}$