Assignment 1

Due: 3:00pm on Tuesday, February 2, 2016

You will receive no credit for items you complete after the assignment is due. Grading Policy

Problem 12.60

On the afternoon of January 15, 1919, an unusually warm day in Boston, a 27.4-m-high, 27.4-m-diameter cylindrical metal tank used for storing molasses ruptured. Molasses flooded into the streets in a 9-m-deep stream, killing pedestrians and horses, and knocking down buildings. The molasses had a density of $1600\,\mathrm{kg/m^3}$.

Part A

If the tank was full before the accident, what was the net outward force the molasses exerted on its sides? (*Hint:* Consider the outward force on a circular ring of the tank wall of width dy and at a depth y below the surface. Integrate to find the total outward force. Assume that before the tank ruptured, the pressure at the surface of the molasses was equal to the air pressure outside the tank.)

ANSWER:

F = 5.07×10^{8} N

Correct

$F = pA$

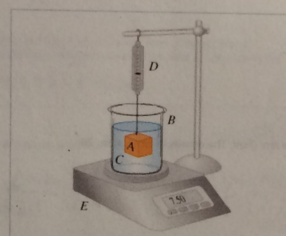
$dA = (2\pi R)dy$

$F = \rho g \pi R h^2$

$F = 5.07\times10^{8} N$

Problem 12.72

Block *A* in the figure hangs by a cord from spring balance *D* and is submerged in a liquid *C* contained in beaker *B*. The mass of the beaker is 1.05 kg ; the mass of the liquid is 2.25 kg . Balance *D* reads 3.00 kg and balance *E* reads 7.50 kg. The volume of block *A* is $3.95\times10^{-3}\,\mathrm{m^3}$.



$F_D + F_E - (w_A + w_B + w_C) = 0$

$m_A = m_D + m_E - m_B - m_C$

$m_A = 3 + 7.50 - 1.05 - 2.25$

$m_A = 7.2$

Part A

What is the density of the liquid?

ANSWER:

ρ_{liquid} = 1060 $\mathrm{kg/m^3}$

Correct

$\rho = \frac{m_A - m_D}{V_A} = \frac{7.2-3}{3.95\times10^{-3}} = 1063 \frac{kg}{m^3}$

Part B

What will the balance *D* read if block *A* is pulled up out of the liquid?

ANSWER:

m_D = 7.20 kg

$m_A = m_D = 7.2 kg$

Correct

Part C

What will the balance *E* read if block *A* is pulled up out of the liquid?

ANSWER:

m_E = 3.30 kg

$2.25 + 1.05 = 3.3 kg$

Correct

Problem 12.80

A cylindrical bucket, open at the top, is 28.0 cm high and 14.0 cm in diameter. A circular hole with a cross-sectional area

1.67 cm is cut in the center of the bottom of the bucket. Water flows into the bucket from a tube above it at the rate of 2.59×10^{-4} m^3/s.

Part A

How high will the water in the bucket rise?

ANSWER:

h = 12.3 cm

Correct

$P_1 + \rho g y_1 + \frac{1}{2}\rho v_1^2 = P_2 + \rho g y_2 + \frac{1}{2}\rho v_2^2$

$v_2 A_2 = 2.59\times10^{-4}$

$v_2 = \frac{2.59\times10^{-4}}{1.67\times10^{-4}}$

$v_2 = 1.55 m/s$

$A_1 >> A_2$, neglect $\frac{1}{2}\rho v_1^2$

$P_a + \rho g h = P_a + \frac{1}{2}\rho v_2^2$

$h = \frac{v_2^2}{2g} = \frac{(1.55)^2}{2(9.8)} = 12.3 cm$

Problem 12.82

In 1993 the radius of Hurricane Emily was about 350 km. The wind speed near the center ("eye") of the hurricane, whose radius was about 30 km, reached about 200 km/h. As air swirled in from the rim of the hurricane toward the eye, its angular momentum remained roughly constant.

Part A

Estimate the wind speed at the rim of the hurricane.

Express your answer using two significant figures.

ANSWER:

v = 17 km/h

Correct

$200\ km/h\left(\frac{30}{350}\right) = 17 km/h$

Part B

Estimate the pressure difference at the earth's surface between the eye and the rim. (*Hint:* The density of air (1 atm, 20 °C) is 1.20 kg/m^3.)

Express your answer using two significant figures.

ANSWER:

ΔP = -1800 Pa

Correct

$\Delta P = \frac{1}{2}(1.2)(200^2 - 17^2)\left(\frac{1 m/s}{3.6 km/h}\right)^2$

$\Delta P = 1800 Pa$

Part C

Where is the pressure greater?

ANSWER:

- at the eye
- at the rim

Correct

Part D

If the kinetic energy of the swirling air in the eye could be converted completely to gravitational potential energy, how high would the air go?

Express your answer using two significant figures.

ANSWER:

h = 160 m

Correct

$\cancel{m}gh = \cancel{m}v^2\frac{1}{2}$

$9.8h = (200 \div 3.6)^2\frac{1}{2}$

$h = 157.5 m$

Exercise 17.22

A brass rod is 185 cm long and 1.60 cm in diameter.

Part A

What force must be applied to each end of the rod to prevent it from contracting when it is cooled from 120 °C to 10 °C?

Express your answer using two significant figures.

R:

0×10^4 N

Correct

$F = -Y\alpha \Delta T A$

$= -(0.9\times10^{11})(2\times10^{-5})(-110)(2.01\times10^{-4})$

$= 4\times10^4 N$

Exercise 17.38

opper calorimeter can with mass 0.100 kg contains 0.160 kg of water and 0.018 kg of ice in thermal equilibrium at ospheric pressure.

Part A

If 0.750 kg of lead at a temperature of 255 °C is dropped into the calorimeter can, what is the final temperature? Assume that no heat is lost to the surroundings.

ANSWER:

$T =$ 21.4 °C

Correct

$Q_i = m_i L_F + m_i c_w \Delta T_w$

$Q_i = (0.018)(3.34\times10^5) + (0.018)(4.19)(T-0) = 39T$

$Q_w = m_w c_w \Delta T_w = (0.16)(4.19)(T-0) = 670.4T$

$Q_c = m_c c_c \Delta T_c = (0.1)(390)(T-0) = 39T$

$Q_L = m_L c_L \Delta T_L = (0.75)(130)(T-255) =$

$97.5T - 2.48\times10^4$

$2.486\times10^4 = 97.5T + 39T + 670.4T + 39T$

$T = 21.4°C$

Problem 17.96

A Styrofoam bucket of negligible mass contains 1.75 kg of water and 0.450 kg of ice. More ice, from a refrigerator at 15.0 °C, is added to the mixture in the bucket, and when thermal equilibrium has been reached, the total mass of ice in the bucket is 0.884 kg.

$0.884 - 0.45 = 0.434$

Part A

Assuming no heat exchange with the surroundings, what mass of ice was added?

Express your answer with the appropriate units.

ANSWER:

$m =$ 0.397 kg

All attempts used; correct answer displayed

$m_i c_i (15) + (-0.434 m_i) L_F = 0$

$m_i = \frac{0.45 L_F}{c_i(15) + L_F} = \frac{(0.434)(334\times10^3)}{(2100)(15) + 334\times10^3}$

$m_i = 0.397 kg$

Exercise 17.58

One end of an insulated metal rod is maintained at 100 °C and the other end is maintained at 0.00 °C by an ice–water mixture. The rod has a length of 60.0 cm and a cross-sectional area of 1.30 cm^2. The heat conducted by the rod melts a mass of 9.25 g of ice in a time of 15.0 min.

Part A

Find the thermal conductivity k of the metal.

ANSWER:

$k =$ 158 W/(m·K)

Correct

$L_F = 3.34\times10^5$

$Q = mL_F = (9.25\times10^{-3})(3.34\times10^5)$

$= 3090$

$\frac{Q}{t} = \frac{3090}{900} = 3.43 W$

$k = \frac{(Q/t)(L)}{A(T_H - T_C)}$

$k = \frac{3.43(0.6)}{(1.23\times10^{-4})(100)} =$

Problem 17.106

The rate at which radiant energy from the sun reaches the earth's upper atmosphere is about 1.50 kW/m^2. The distance from the earth to the sun is 1.50×10^{11} m, and the radius of the sun is 6.96×10^8 m.

Part A

What is the rate of radiation of energy per unit area from the sun's surface?

ANSWER:

$\frac{\Delta H}{\Delta A} =$ 6.97×10^7 W/m^2

Correct

$\frac{\Delta H}{\Delta A} = I_2 = (1.5\times10^3)\left[\frac{1.5\times10^{11}}{6.96\times10^8}\right]^2$

$\frac{\Delta H}{\Delta A} = 6.97\times10^7 W/m^2$

Part B

If the sun radiates as an ideal blackbody, what is the temperature of its surface?

ANSWER:

T = 5920 K

$e = 1$

$T = \left[\frac{\cancel{A}}{A} \frac{1}{\sigma}\right]^{\frac{1}{4}}$ $\rightarrow$ $T = \left[\frac{6.97\times10^{7}}{5.67\times10^{-8}}\right]^{\frac{1}{4}} = 5920k$

Correct

Problem 18.52

During a test dive in 1939, prior to being accepted by the U.S. Navy, the submarine *Squalus* sank at a point where the depth of water was 73.0 m. The temperature at the surface was 27.0 $^\circ\mathrm{C}$ and at the bottom it was 7.0 $^\circ\mathrm{C}$. The density of seawater is 1030 $\mathrm{kg/m^3}$.

Part A

A diving bell was used to rescue 33 trapped crewmen from the *Squalus*. The diving bell was in the form of a circular cylinder 2.30 m high, open at the bottom and closed at the top. When the diving bell was lowered to the bottom of the sea, to what height did water rise within the diving bell? (*Hint:* You may ignore the relatively small variation in water pressure between the bottom of the bell and the surface of the water within the bell.)

ANSWER:

$h'=h\left(\frac{P}{P'}\cdot\frac{T'}{T}\right)$

$h' = 2.3\left(\frac{1.013\times10^5}{1.013\times10^5+1030\cdot9.8\cdot73}\right)\left(\frac{280.15}{300.15}\right) = 0.26$

$h-h' = 2.3-0.26 = 2.04\,m$

h = 2.04 m

Correct

Part B

At what gauge pressure must compressed air have been supplied to the bell while on the bottom to expel all the water from it?

ANSWER:

p = 7.37×10^5 Pa

Correct

Score Summary:

Your score on this assignment is 88.1%.
You received 88.05 out of a possible total of 100 points.