

STATE ANY ASSUMPTIONS YOU NEED TO MAKE — SHOW ALL WORK — CIRCLE ANY FINAL ANSWERS
 USE YOUR TIME WISELY — WORK ON WHAT YOU CAN — BE SURE TO WRITE DOWN EQUATIONS
 INCLUDE ANY FREE BODY DIAGRAMS FOR FORCE PROBLEMS — FEEL FREE TO ASK ANY QUESTIONS

TITANIC — DENSITY AND WATER (50,000 POINTS) — FIRST VERSION —

$\rho_{\text{sea water}} = 1030 \text{ kg/m}^3$

1.) On the evening before *Titanic* sank, there was some concern that as the temperature dropped, that some tanks of drinking water might freeze. If there was 5000 kg of water in a tank, and $T_0 = 10^\circ\text{C}$, then find the energy needed to (a) cool the water to freezing and (b) to freeze the water into ice. $c = 4186 \text{ J/kg}\cdot^\circ\text{C}$ $L_f = 3.33 \times 10^5 \text{ J/kg}$



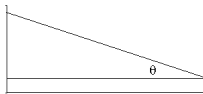
(c) *RMS Titanic* was about 800 feet long (245 meters), with a mass of 40,900,000 kg (that would correspond to a displacement of about 45,000 tons), and according to the numbers painted on the bow of the ship, she was drafting about 37 feet (11.3 meters) — that means that 11.3 meters of the ship was below the water. Assume that the part of the ship under the water is a rectangular box with these dimensions — what is the width of this box — and hence the width of the ship? Should your calculation be too big or too small? Why?



"Take her to sea, Mr. Murdoch. Let's stretch her legs."

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A rod 5.00 m long and mass 25.0 kg is held to the wall without moving by a force F_1 , where the rod is attached to the wall and by a cable, where $\theta = 17^\circ$. Set up *but do not solve* the equations from the relevant (d) Free Body and (e) Free Rotation Diagram.



TITANIC — STRETCHING THE TRUTH (50,000 POINTS)

2.) ★(a) We can use take the equation for the Young's Modulus, and use it to find $F(x)$, the force as a function of the stretch (let $x = \Delta L$). Find the work needed to stretch a 0.00800 m diameter steel cable ($Y = 20.0 \times 10^6 \text{ N/m}^2$) from 10.0 m to 11.0 m, by integrating $W = \int F(x)dx$

An acceleration is found to be $a(t) = C t^5$, where $C = 15 \text{ m/s}^7$. Find ★(b) v and ★(c) x at $t = 3.21 \text{ sec}$. Assume x_0 and v_0 are both zero.

(d) A wheel of mass 5.37 kg ($r = 1.38 \text{ m}$) undergoes Uniform Circular Motion with $a_c = 7.00 \text{ m/s}^2$. Find the *torque* that the centripetal force applies to the wheel.

★(e) Starting from the description of the motion of an object of mass m undergoing S.H.M. as $x(t) = A \sin(\omega t)$, find the force, $F(t)$, acting on the object using Newton's form of his second law, $F = dp/dt$.



**TITANIC – ENGINE ROOM (50,000 POINTS)**

3.) (a) Suppose the two positions in one piston in the starboard side engine (that's the engine on the right side of the ship), corresponds to $P_1 = 1,010,300$ Pa, $V_1 = 1.00$ m³ and $T_1 = 473$ K and $P_2 = 101,300$ Pa, and $T_2 = 373$ K. Use the Ideal Gas to find V_2 .

(b) If the area of the piston is 1.00 m², then what is the net force on the piston at P_2 , T_2 , V_2 , assuming the outside air pressure is $P_0 = 101,300$ Pa ?

(c) If T_1 and T_2 in part (a) were to correspond to the reservoir temperatures, then identify and calculate one of the three efficiencies we studied.

(d) What is the kinetic energy of the *Titanic* at 23 knots ($42,55$ km/hour = 11.82 m/s)?

(e) Ignoring drag forces, if the Second Law Efficiency is 86% (0.86), how much energy is wasted to bring the ship up to speed from rest?

**TITANIC – COLLISIONS & PHYSICAL ATTRACTION (50,000 POINTS)**

4.) If the iceberg (at rest) was 1000 times the mass of *Titanic* ($40,900,000$ kg and $v = 11.82$ m/s) and it had collided *inelastically*, then what would the speed of the wreck have been?

(b) The *Titanic* was steaming due west 23 knots (11.82 m/s) – that's to the left. The iceberg is 30.0 seconds ahead. To miss the iceberg, it needed to add an additional velocity component to the south, such that it will move 120.0 m in the 30.0 seconds. Find the total vector velocity, \vec{v} , in standard form.



(c) Rose DeWitt Bukater ($m = 58.0$ kg) and Jack Dawson ($m = 64.0$ kg) are one foot apart ($r = 0.305$ meters). Find the force of the gravitational attraction between them. $G = 6.67 \times 10^{-11} \text{ N}\cdot\text{m}^2/\text{kg}^2$.

(d) A whistle consists of a tube 5.00 cm (0.0500 m), open at both ends. Find f and λ of the fundamental standing wave, if $c_s = 345$ m/s.

(e) If the *Titanic* was 245.000 meters long at 68°F (20.0°C), then what was the length of the ship at time of its sinking, assuming that the temperature of the sea water was -2.2°C? $\alpha_{\text{iron}} = 12 \times 10^{-6} \text{ }^\circ\text{C}^{-1}$

