CollegeBoard
Advanced Placement
Program

AP® Physics B (Operational)
2004 Sample Student Responses

A1

2. (15 points)

While exploring a sunken ocean liner, the principal researcher found the absolute pressure on the robot observation submarine at the level of the ship to be about 413 atmospheres. The density of seawater is 1025 kg/m^3.

(a) Calculate the gauge pressure p_g on the sunken ocean liner.

1 atm = 1×10^5 Pa   413 atm = 4.13×10^7 Pa

Abs. Pressure = 4.13×10^7 Pa

gauge pressure = abs. pressure − inital pressure

$4.13 \times 10^7 - 1 \times 10^5 = 4.12 \times 10^7$ Pa

(b) Calculate the depth D of the sunken ocean liner.

$P = P_0 + \rho g h$ $P - P_0 = \rho g h$

$4.13 \times 10^7 - 1 \times 10^5 = \rho h$ $4.12 \times 10^7 = \rho g h$

$h = \frac{4.12 \times 10^7}{\rho g}$ $h = \frac{4.12 \times 10^7}{1025(9.8)}$ $h = 4101.54$ m

h = d   d = 4101.54 m

(c) Calculate the magnitude F of ~~the force due to the~~ water on a viewing port of the submarine at this depth if the viewing port has a surface area of 0.0100 m^2.

$P = \frac{F}{A}$ $F = PA$ $F = 4.13 \times 10^7 (0.01 m^2)$

F = 413000 N

A2

Suppose that the ocean liner came to rest at the surface of the ocean before it started to sink. Due to the resistance of the seawater, the sinking ocean liner then reached a terminal velocity of $10.0\,\text{m/s}$ after falling for 30.0 s.

(d) Determine the magnitude a of the average acceleration of the ocean liner during this period of time.

$v_f = \cancel{v_i} + aT$ ~~10 = 0 + a~~

$v_i = 0$
$v_f = 10$
$T = 30$

$a = \frac{v_f}{T}$ $a = \frac{10}{30} = \frac{1}{3} = \boxed{0.333\ m/s^2}$

(e) Assuming the acceleration was constant, calculate the distance d below the surface at which the ocean liner reached this terminal velocity.

$d = \cancel{v_i t} + \frac{1}{2}aT^2$

$v_i = 0$
$v_f = 10$
$T = 30$
$a = 0.333$

$d = \frac{1}{2}aT^2$ $d = \frac{1}{2}(0.333)(30)^2$

$d = 150\text{m}$ below the surface

(f) Calculate the time t it took the ocean liner to sink from the surface to the bottom of the ocean.

AT $t = 30\,s$, $d = 150\,m$.

$d = v_i t + \cancel{\frac{1}{2}aT^2}$

$d = d_{tot} - d_{initial}$
$d = 4101.54 - 150$
$d = 3951.54\,m$

$t_A = 30\,s$

$t_B = \frac{d}{v_i}$ $t = \frac{3951.54}{10}$ $t_B = 395.154\,s$

$T_{total} = T_A + T_B$

$T_{total} = 30\,s + 395.154\,s$

$T_{total} = 425.154\,s$

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2. (15 points)

While exploring a sunken ocean liner, the principal researcher found the absolute pressure on the robot observation submarine at the level of the ship to be about 413 atmospheres. The density of seawater is 1025 kg/m^3.

(a) Calculate the gauge pressure p_g on the sunken ocean liner.

413 atm / 1 · 1.0 x 10^5 Pa / atm

413 x 10^5 Pa

4.13 x 10^7 Pa

(b) Calculate the depth D of the sunken ocean liner.

4.13x10^7 Pa = 1.0x10^5 + ρgh

4.12x10^7 = 1025 kg/m (9.8 m/s²) h

4,101 m = h

(c) Calculate the magnitude F of the force due to the water on a viewing port of the submarine at this depth if the viewing port has a surface area of $0.0100\ \text{m}^2$.

413 atm = 1.0 atm + water pressure

412 atm = water pressure

4.12 x 10^7 Pa

4.12x10^7 Pa / .0100 m² = 4.12 x10^9 N

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B2

Suppose that the ocean liner came to rest at the surface of the ocean before it started to sink. Due to the resistance of the seawater, the sinking ocean liner then reached a terminal velocity of 10.0 m/s after falling for 30.0 s.

(d) Determine the magnitude a of the average acceleration of the ocean liner during this period of time.

$v = v_0 + at$

$10\,m/s = 0\,m/s + a(30s)$

$10\,m/s = a(30s)$

$\frac{1\,m}{3\,s^2} = a$

$.333\,m/s^2 = a$

(e) Assuming the acceleration was constant, calculate the distance d below the surface at which the ocean liner reached this terminal velocity.

$x = x_0 + v_0 t + \frac{1}{2}(a)(t)^2$

$x = 0 + 0 + \frac{1}{2}(.333)(30)^2$

$x = 150\,m$

(f) Calculate the time t it took the ocean liner to sink from the surface to the bottom of the ocean.

30 sec for 150 m

4,101 − 150 = 3,951 m to bottom of ocean

$t = \frac{x}{v}$

$t = \frac{3,951\,m}{10\,m/s}$

$t = 395.1\,sec$

395.1 sec
+ 30 sec
425.1 sec

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