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Gravity and Planetary Motion

1\. a) We know that planet X acceleration is 10 x planet earth

i) Planet X and Earth rasio?

$R_x = R_e$

The mass of the planet can be expressed as:

$$\frac{M_x}{M_e} = \frac{g_x \, R_x^2}{G} \cdot \frac{G}{g_{earth} R_e^2}$$

Because the size is the same, we can cancle the Radius of the planet.

$$\frac{M_x}{M_e} = \frac{g_x}{g_{earth}}$$

we know that : $g_x = 10\, g_{eart}$

$$\frac{M_x}{M_e} = \frac{10 \cdot g_{earth}}{g_{earth}} = \frac{10}{1}$$

So the ratio is $M_x : M_e = 10 : 1$

ii) Now we know that $M_e = M_x$

We can expressed by using this equation

$$\frac{M_x}{M_e} = \frac{g_x \, R_x^2}{g_{earth} R_e^2}$$

$$\frac{R_e^2}{R_x^2} = \frac{g_x}{g_{earth}} \quad ; \quad g_x = 10\, g_{earth}$$

$$\frac{R_e^2}{R_x^2} = \frac{10\, g_{earth}}{g_{earth}} = \frac{10}{1}$$

$$\frac{R_x^2}{R_e^2} = \frac{1}{10}$$

$$\frac{R_x}{R_e} = \frac{1}{\sqrt{10}}$$

So the rasio of the new planet and the earth is $1 : \sqrt{10}$

iii) If we dont now the size and the mass of the planet, we find out the mass by our own weight.

Using Newton Gravitational Law

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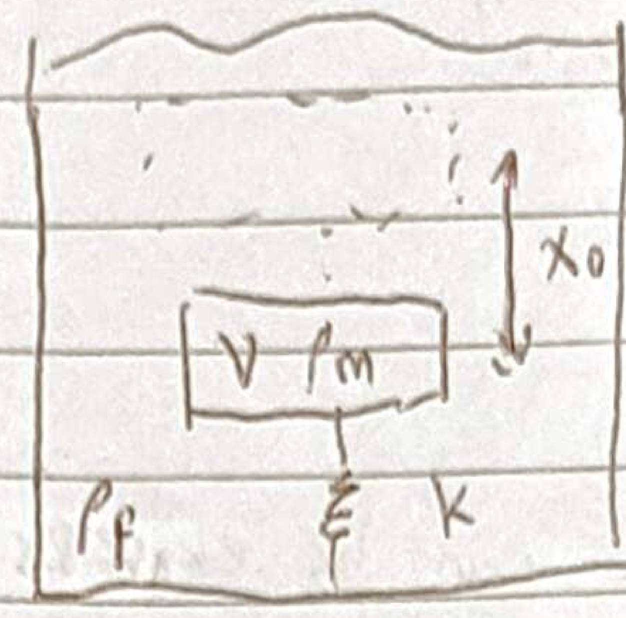
b) i) If the planet moves in eliptical, the equation will be:

$$T^2 = r^3 \longrightarrow \text{Kepler's Law}$$

ii) The circular motion of a planet is a special case because the gravitational influence of planet and the sun must be in the magnitude. This will make the path of the earth goes in perfectly circular. When we know that the Sun or Stars is not weak in gravitational forces, that is why the circular orbits is a very special case and verry rare happening in real life.

2 Under water Oscillator



a) Find spring displacement

The Bouyant Force must be the same magnitude as the spring force and the weight of the block. So we can express the model as:

$$F_B = F_{spr} + W$$
$$\rho_f V_f \cdot g = k\Delta x + \rho_m V g$$

The V_f is the volume of the fluid that is displaced. Because the block is fully submerged, $V_f = V$

$$\rho_f V g - \rho_m V g = k\Delta x$$
$$\frac{Vg(\rho_f - \rho_m)}{k} = \Delta x$$

$$\Delta x = x_0 - x_{eq}$$

$$x_0 - x_{eq} = \frac{Vg(\rho_f - \rho_m)}{k}$$

b) We know that

$$F = ma \quad \text{and} \quad F_{sp} = -k\Delta x$$
$$ma = m\frac{d^2x}{dt^2} = m\ddot{x}$$
$$m\ddot{x} = -k\Delta x = -k(x_{eq} - x)$$
$$m\ddot{x} + k(x_{eq} - x) = 0$$
$$\ddot{x} + \frac{k}{m}x = 0$$

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$C=0 = \ddot{x} + \frac{k}{m}x = 0$

while $\ddot{x} = g$ and $\omega = \frac{k}{m}$

$(x_{eq} - x) = -Vg(\rho_f - \rho_m)/k$

$$g - \frac{\omega Vg(\rho_f - \rho_m)}{k} = C$$

c) $\omega = \sqrt{\frac{k}{m}} = \sqrt{\frac{k}{\rho_m V}}$

$\omega = \frac{2\pi}{T} = 2\pi f$

The Periode :

$$\frac{2\pi}{T} = \sqrt{\frac{k}{\rho_m V}}$$

$$T = 2\pi\sqrt{\frac{\rho_m V}{k}}$$

The frequency :

$$f = \frac{1}{2\pi}\sqrt{\frac{k}{\rho_m V}}$$

d) $x(t) = A + B\sin(\omega t + \phi)$

- A is the equilibrium position x_{eq}

$$x_{eq} = x_0 - \frac{Vg(\rho_f - \rho_m)}{k}$$

- B is the amplitude $= x_0$

- $\omega = \sqrt{\frac{k}{\rho_m V}}$

- ϕ is the initial phase, because it's displaced from the equilibrium position, the value of ϕ is $= 0$

The equation will be

$$x(t) = x_0 - \frac{Vg(\rho_f - \rho_m)}{k} + x_0 \sin\left(\sqrt{\frac{k}{\rho_m V}}\,t + 0\right)$$

$$x(t) = x_0 - \frac{Vg(\rho_f - \rho_m)}{k} + x_0 \sin\left(\sqrt{\frac{k}{\rho_m V}}\,t\right)$$

e) The liquids density will not affect the amplitued and the period from this equation :

Amplitude : $x_0 \sin\left(\sqrt{\frac{k}{\rho_m V}}\,t\right)$

There is no ρ_f property.

Periodes : $T = 2\pi\sqrt{\frac{\rho_m V}{k}}$

There is no ρ_f property.

f) Gravity will not change the period or amplitude because

Periodes $= 2\pi\sqrt{\frac{\rho_m V}{k}}$ and

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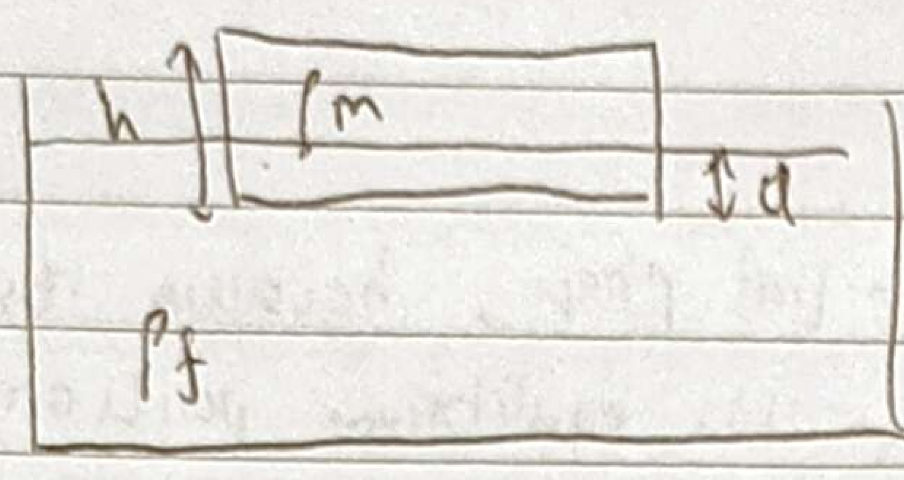
Amplitudes : $X_0 \sin\left(\sqrt{\frac{k}{\rho_m V}}\, t\right)$,,

There is no gravity property in both equations.

3. Oscillation of Floating Body



a) we know that $F_{Bouyant} = Weight$

$F_{Bouyant} = \rho_f \cdot V_f \cdot g = F_B$

$Weight = \rho_m \cdot V_{block}\, g = W$

Gravitational acceleration can be canceled.

$F_B = W$
$\rho_f \cdot V_f = \rho_m \cdot V_{block}$

We know that $V_{blocks} = A \cdot h$
and $V_f = A \cdot d$

A = area can be cancled because its the same value

so : $\rho_f\, d = \rho_m\, h$
$d = \frac{\rho_m}{\rho_f} h$,,

b) $Weight = F_{Bouyant}$
$m \cdot g = \rho_f \cdot A\, \Delta d \cdot g$

c) Find the periodes

$$\omega = \sqrt{\frac{k}{m}} = \sqrt{\frac{F_B/\Delta x}{\rho_m A \cdot h}}$$

$$\frac{2\pi}{T} = \sqrt{\frac{\frac{\rho_f \cancel{A} \cancel{d}}{\cancel{d}}}{\rho_m \cancel{A} h}}$$

$$\frac{2\pi}{T} = \sqrt{\frac{\rho_f}{\rho_m h}}$$

$$T = 2\pi \sqrt{\frac{\rho_m h}{\rho_f}}$$,

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4) Engenerry Aplication

a) $ps = (\rho \cdot g \cdot (H + z)) + B$

$= \rho g H + \rho g Z + B$ //

b) $P_1 + \frac{1}{2}\rho V_1^2 + \rho g h + \cancel{B} = \cancel{B}$

$P_1 = -\frac{1}{2}\rho v_1^2 - \rho g h$

$= -\rho\left(\frac{1}{2}V - g(H+Z)\right)$ //

c) Bernouliy equations.

$\cancel{B} + P_1 + \frac{1}{2}\rho v^2 + \rho g h_1 = P_2 + \frac{1}{2}\rho v^2 + \rho g h + \cancel{B}$

$P_1 + \frac{1}{2}\rho V^2 + \cancel{\rho g (H+Z)} = P_2 + \frac{1}{2}\rho (0)^2 + \cancel{\rho g (H+Z)}$

$\frac{1}{2}\rho v^2 = P_2 - P_1$

$V^2 = \frac{2(P_2 - P_1)}{\rho}$

$V = \sqrt{\frac{2 P_2 - P_1}{\rho}}$