Name________________________

May 8, 2001

Phys 121 — Spring 2001
Final Exam

1.		(6)
2.		(9)
3.		(12)
4.		(6)
5.		(10)
6.		(12)
7.		(8)
8.		(17)
MC		(20)
Total		(100)

Multiple Choice

1. $1\,\frac{\text{g}}{\text{cm}^2}$ is equal to

a) $0.10\,\frac{\text{kg}}{\text{m}^2}$
b) $1.0\,\frac{\text{kg}}{\text{m}^2}$
c) $10\,\frac{\text{kg}}{\text{m}^2}$
d) $1000\,\frac{\text{kg}}{\text{m}^2}$

2. The angular momentum of a system of objects is conserved when:

a) There is no net external force.
b) There is no net external torque.
c) The objects exert no friction–type forces on one another.
d) The objects exert no electromagnetic forces on one another.

3. A physics instructor holds two masses with arms outstretched; he stands on a platform rotating freely with an angular speed of $6.0\,\frac{\text{rad}}{\text{s}}$. He pulls his arms inward and then has half of his former moment of inertia. His final angular speed is:

a) $3.0\,\frac{\text{rad}}{\text{s}}$
b) $6.0\,\frac{\text{rad}}{\text{s}}$
c) $12.0\,\frac{\text{rad}}{\text{s}}$
d) $24.0\,\frac{\text{rad}}{\text{s}}$

4. A simple pendulum is 2.0 m long. How long would it have to be to triple the period?

a) 0.666 m long.

b) 6.0 m long.

c) 18.0 m long.

d) 54.0 m long.

5. The speed of waves on a stretched string A is 400 $\frac{m}{s}$. String B is under twice as much tension as string A and its linear mass density is half as great as that of string A. The speed of waves on string B is:

a) 100 $\frac{m}{s}$

b) 400 $\frac{m}{s}$

c) 800 $\frac{m}{s}$

d) 1600 $\frac{m}{s}$

6. What is the angular speed of the minute (big) hand of a clock?

a) $1.75 \times 10^{-3}\ \frac{rad}{s}$.

b) $5.24 \times 10^{-2}\ \frac{rad}{s}$.

c) $1.05 \times 10^{-1}\ \frac{rad}{s}$.

d) $2.26 \times 10^{4}\ \frac{rad}{s}$.

7. A uniform disk, a solid sphere and a hoop all with the same mass M and radius R are rolling along a flat surface with *same* linear speed v. The ranking of their kinetic energies goes as:

a) $KE_{sphere} > KE_{disk} > KE_{hoop}$.

b) $KE_{sphere} > KE_{hoop} > KE_{disk}$.

c) $KE_{disk} > KE_{sphere} > KE_{hoop}$.

d) $KE_{hoop} > KE_{disk} > KE_{sphere}$.

8. What is the range of sound frequencies which can be heard by a healthy young human?

a) 5 Hz to 5,000 Hz.

b) 20 Hz to 20,000 Hz.

c) 100 Hz to 40,000 Hz.

d) 500 Hz to 100,000 Hz.

9. A spring requires a force of 1.0 N to compress it by 0.10 m. How much work is required to stretch the spring by 0.40 m?

a) 0.40 J

b) 0.60 J

c) 0.80 J

d) 2.0 J

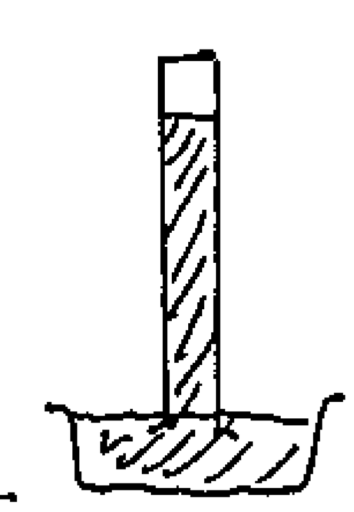
10. We take a regular barometer to a planet where the atmospheric pressure is the same as that on earth but the value of g is half as large. As compared with its height on the earth, the height of the fluid in the barometer is

a) Half as large.

b) The same.

c) Twice as large.

d) None of the above.



P = same as on earth

g' = half of earth's g

Problems

1. *Units? Units?* What are the appropriate MKS (SI, metric) units for the following quantities: (6)

a) Angular Momentum

$kg \cdot m^2 / s$

b) Pressure

$Pa = N/m^2 = \dfrac{kg}{m \cdot s^2}$

c) Volume

m^3

d) Density kg/m^3

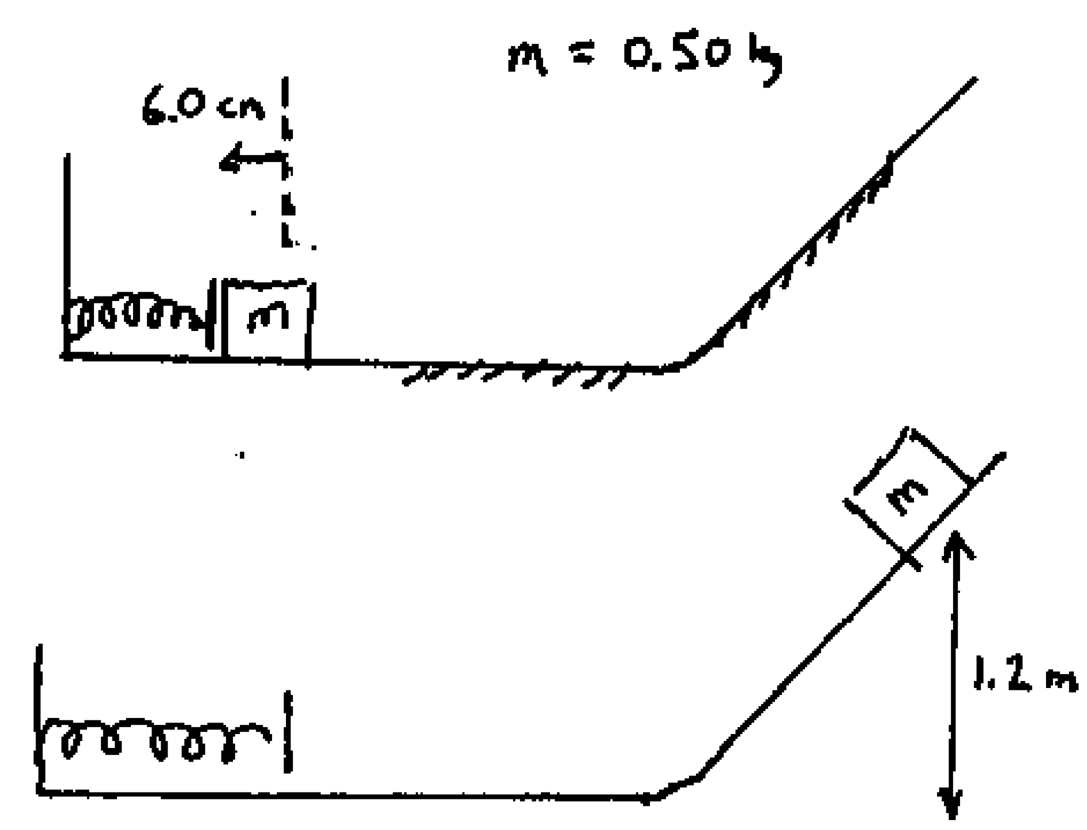
e) Wavelength

m

f) Force constant (of a spring)

$N/m = kg/s^2$

2. A 0.500 kg block is held against a spring with $k = 5000$ N/m, squooshing it from its equilibrium length by 6.0 cm. The mass is released and it then travels over a horizontal surface and up a ramp. The maximum height that it attains on the ramp is 1.20 m.



a) How much energy is stored in the spring initially? (3)

$$PE_{spr} = \tfrac{1}{2}kx^2$$
$$= \tfrac{1}{2}(5000 \tfrac{N}{m})(0.060\,m)^2$$
$$= \boxed{9.00\ J}$$

[& no KE initially]

b) What potential energy of the mass when it has attained maximum height? (2)

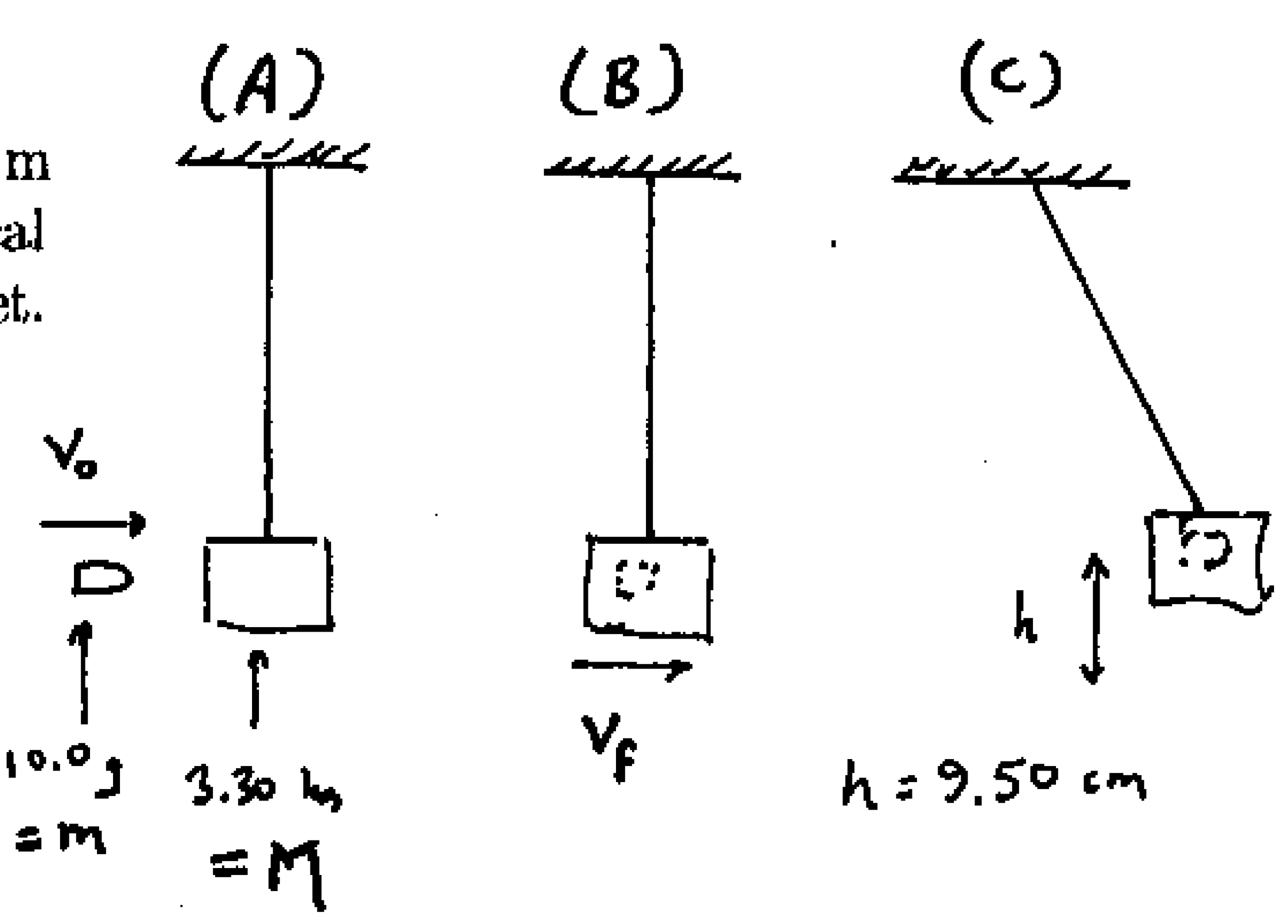
$$PE_{grav} = mgh = (0.50\,kg)(9.8\,\tfrac{m}{s^2})(1.20\,m) = \boxed{5.88\ J}$$

[& no KE in final position]

c) How much work was done by friction as it slid over the surface? (4)

$$W_{fric} = \Delta E = E_f - E_0 = 5.88\ J - 9.00\ J$$
$$= \boxed{-3.12\ J}$$

3. A 10.0 g bullet is fired into a 3.30 kg ballistic pendulum and becomes embedded in it. If the pendulum rises a vertical distance of 9.50 cm, calculate the initial speed of the bullet. (12)



Initial speed of bullet = V_0

Speed of bullet/block just after coll is V_f

Cons. of energy from B to C gives

$$\tfrac{1}{2}(M+m)V_f^2 = (M+m)gh$$

$$V_f^2 = 2gh = 2(9.80\,\tfrac{m}{s^2})(0.095\,m)$$
$$= 1.86\,\tfrac{m^2}{s^2} \qquad V_f = 1.36\,\tfrac{m}{s}$$

Cons of mom between A and B gives:

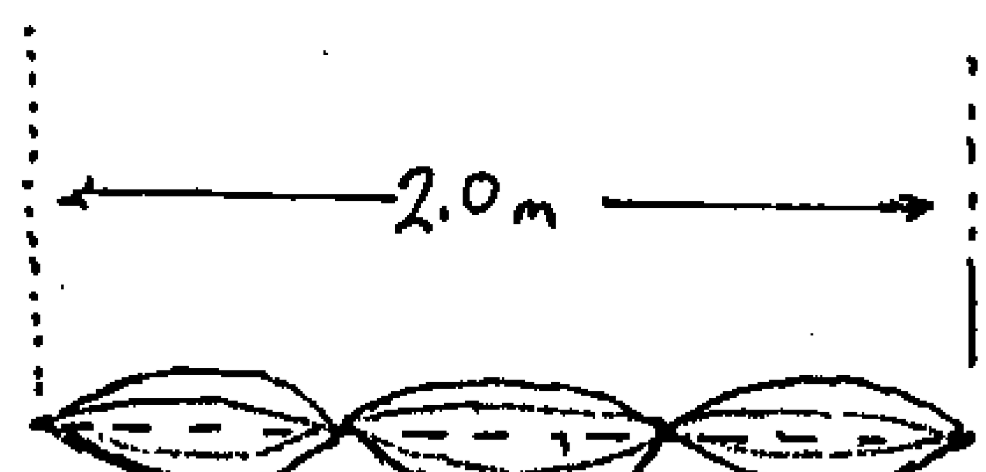
$$mV_0 = (M+m)V_f \qquad V_0 = \frac{(M+m)V_f}{m} = \frac{(3.31\,kg)(1.36\,\frac{m}{s})}{(0.010\,kg)} = \boxed{452\,\tfrac{m}{s}}$$

4. The net work done in accelerating a propeller from rest to and angular speed of 106 rad/s is 1500 J.

What is the moment of inertia of the propeller? (6)

$$W_{net} = \Delta KE = KE_f - \underbrace{KE_o}_{\text{init at rest}} = KE_f = \tfrac{1}{2} I \omega_f^2$$

$$I = \frac{2 W_{net}}{\omega_f^2} = \frac{2(1500\,J)}{(106\,/s)^2} = \boxed{0.267\ kg\,m^2}$$



5. When a stretched string of length 2.0 m is under 15.0 N of tension and its end is oscillated at a frequency of 170 Hz, the standing wave pattern shown at the right is seen.

a) What is the wavelength of the standing wave? (3)

$$L = 2.0\,m = 3(\lambda/2)$$

$$\lambda = \tfrac{2}{3} L = \tfrac{2}{3}(2.0\,m) = \boxed{1.33\ m}$$

b) What is the speed of waves on the string? (3)

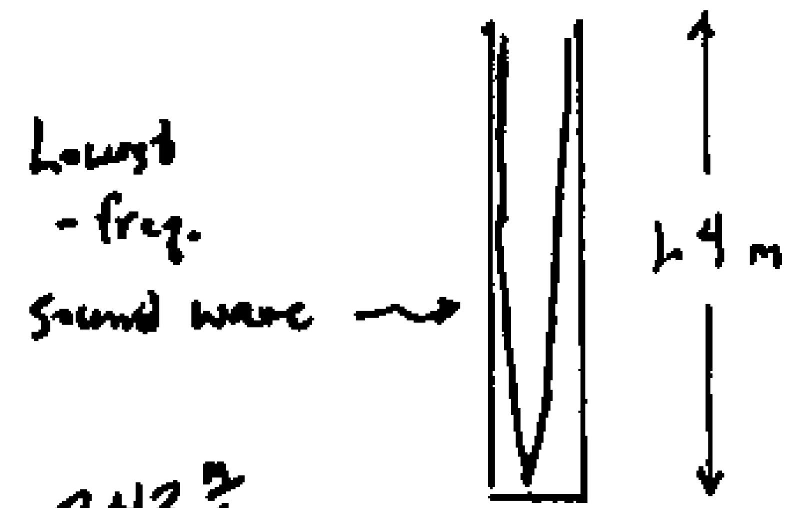
$$v = \lambda f = (1.33\,m)(170\,/s) = \boxed{227\ m/s}$$

c) What is the linear mass density of the string? (4)

$$v = \sqrt{\frac{F}{m/L}} \qquad v^2 = \frac{F}{m/L}$$

$$\frac{m}{L} = \frac{F}{v^2} = \frac{15.0\,N}{(227\,m/s)^2} = \boxed{2.92\times 10^{-4}\ \frac{kg}{m}}$$

6. a) A closed organ pipe has a length of 1.4 m. What is the frequency of the note played by this pipe? (Organ pipe acts like a tube closed at one end; it plays the fundamental (lowest) frequency; speed of sound is 343 $\frac{m}{s}$.) (4)



$1.4\,m = \lambda/4$ for this mode

$\rightarrow \lambda = 4(1.4\,m) = 5.6\,m \qquad f = \frac{v}{\lambda} = \frac{343\,\frac{m}{s}}{5.6\,m} = \boxed{61.2\ Hz}$

b) When a second pipe is played at the same time, a 1.3 Hz beat note is heard. What are the possibilities for the frequency played by the second pipe? (3)

Could be $61.2\ Hz + 1.3\ Hz = \boxed{62.6\ Hz}$

or $61.2\ Hz - 1.3\ Hz = \boxed{60.0\ Hz}$

[Both have an abs. diff. of 1.3 Hz with the freq. of 1st pipe]

c) If we know that the second pipe is longer than the first one, which of the answers given in (b) is the correct one? (1)

Longer pipe → lower frequency → Must be $\boxed{60.0\ Hz}$

d) By how much is the second pipe longer than the first one? (4)

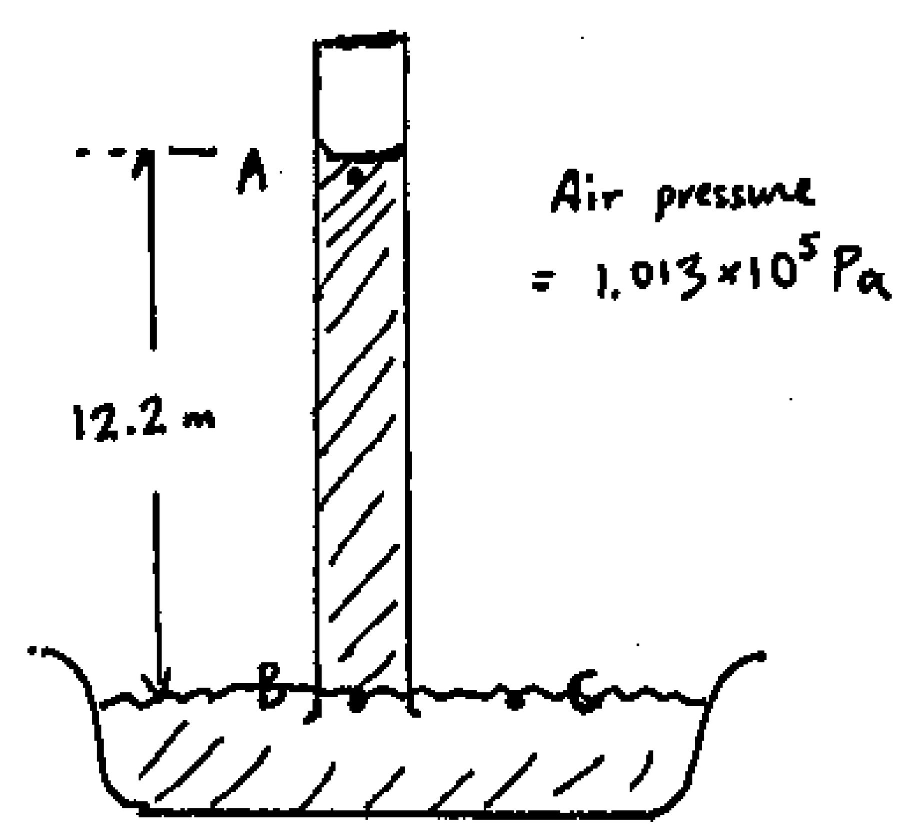
In 2nd pipe,

$\lambda = \frac{v}{f} = \frac{343\,\frac{m}{s}}{60.0\ Hz} = 5.72\ m$

$\rightarrow L = \frac{\lambda}{4} = 1.43\ m \qquad$ 2nd pipe is $\boxed{0.03\ m}$ too long!

7. The largest barometer ever built was an oil-filled barometer constructed in Leicester, England in 1991. The oil had a height of 12.2 m. Assuming a pressure of 1.013×10^5 Pa, what was the density of the oil used in the barometer? (8)

Hint: You may want to consider the points A, B and C in the diagram of the barometer shown at the right. What is the pressure at A (there is a vacuum above it)? What is the pressure at C (there is the atmosphere above it)? How does the pressure at B relate to these values?



$P_A = 0$

$P_B = P_C$ = Atmos. pressure

$= 1.013 \times 10^5\ Pa$

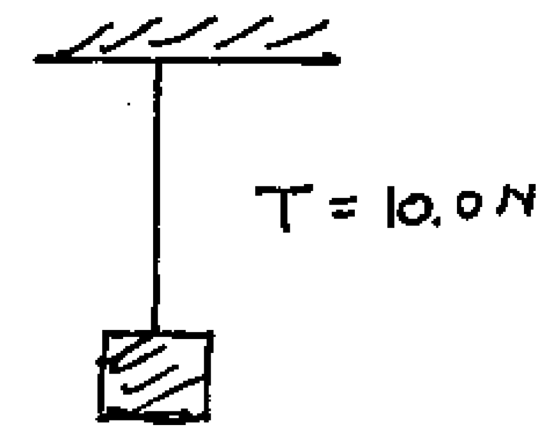
Use $\quad P_B - \underbrace{P_A}_{=0} = \rho_{oil}\, g\, h_{oil\ col.}$

which gives

$P_B = \rho_{oil}\, g\, h_{col}$

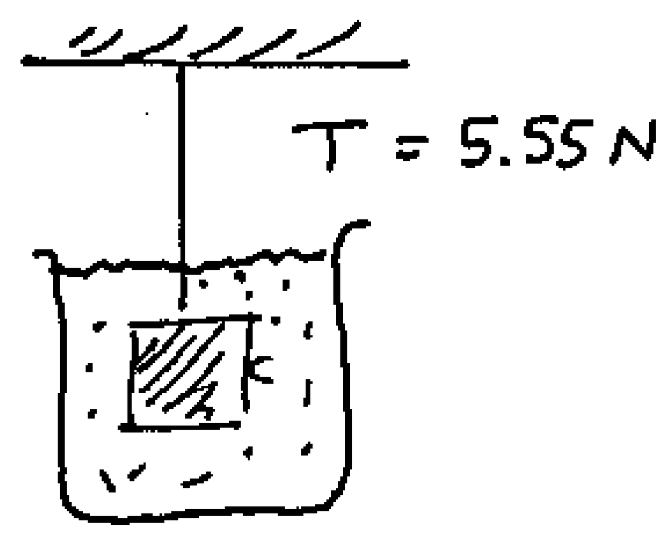
$\rightarrow \rho_{oil} = \frac{P_B}{g\, h_{col}} = \frac{1.013 \times 10^5\ Pa}{(9.8\ \frac{m}{s^2})(12.2\ m)} = \boxed{847\ \frac{kg}{m^3}}$

8. When a solid block of aluminum ($\rho_{Al} = 2700\,\frac{kg}{m^3}$) hangs motionless from a string in air, the tension in the string is 10.0 N (i.e., its weight). When it hangs from a string while submerged in some unknown liquid, the tension in the string is 5.55 N.



a) What is the mass of the block? (2)

$$m = \frac{Wt}{g} = \frac{10.0\,N}{9.8\,\frac{m}{s^2}} = \boxed{1.02\ kg}$$



b) What is the volume of the block? (4)

Since $\rho_{Al} = \frac{m}{V}$

$$V = \frac{m}{\rho_{Al}} = \frac{1.02\ kg}{2700\ \frac{kg}{m^3}} = \boxed{3.78\times10^{-4}\ m^3}$$

c) What is volume of liquid displaced by the block? (1)

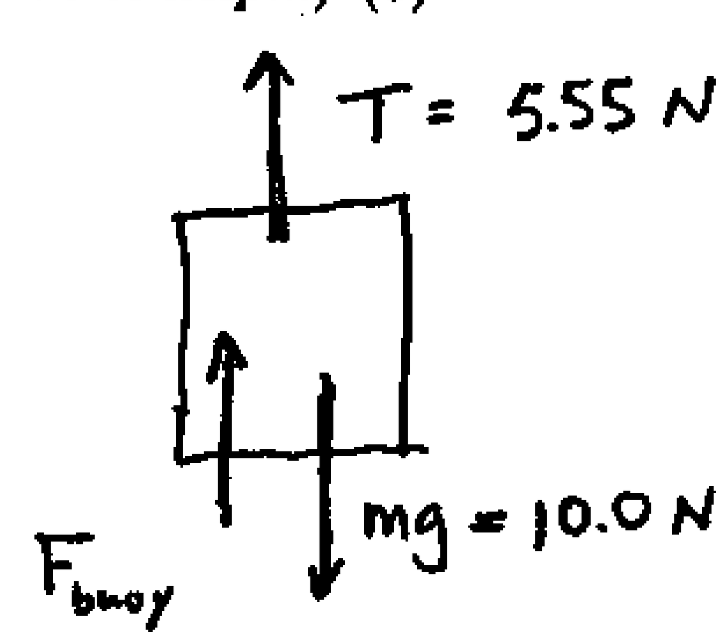
Same as volume of block,

$$V_{disp} = \boxed{3.78\times10^{-4}\ m^3}$$

d) What is the buoyant force acting on the block? *(A free-body diagram can be of help...)* (3)

$$F_{net} = 5.55\,N - 10.0\,N + F_{buoy} = 0$$

$$F_{buoy} = 10.0\,N - 5.55\,N = \boxed{4.45\ N}$$



e) What is the weight of liquid displaced by the block? (1)

Same as F_{buoy}, $\boxed{4.45\ N}$

(by Arch's principle)

f) What is the *mass* of liquid displaced by the block? (2)

$$m_{disp.\,liq} = \frac{Wt_{disp}}{g} = \frac{4.45\,N}{9.8\,\frac{m}{s^2}} = \boxed{0.454\ kg}$$

g) What is the density of the fluid? (4)

$$\rho_{liq} = \frac{m_{disp\,liq}}{V_{disp\,liq}} = \frac{0.454\ kg}{3.78\times10^{-4}\ m^3} = \boxed{1201\ \frac{kg}{m^3}}$$

$$v_x = v_{0x} + a_x t \qquad x = x_0 + v_{0x}t + \tfrac{1}{2}a_x t^2 \qquad v_x^2 = v_{0x}^2 + 2a_x(x - x_0) \qquad x = \tfrac{1}{2}(v_{0x} + v_x)t$$

$$v_y = v_{0y} + a_y t \qquad y = y_0 + v_{0y}t + \tfrac{1}{2}a_y t^2 \qquad v_y^2 = v_{0y}^2 + 2a_y(y - y_0) \qquad y = \tfrac{1}{2}(v_{0y} + v_y)t$$

$$g = 9.80\tfrac{\text{m}}{\text{s}^2} \qquad \mathbf{F}_{\text{net}} = m\mathbf{a} \qquad a_c = \frac{v^2}{r} \qquad F_c = \frac{mv^2}{r} \qquad f_s^{\max} = \mu_s F_N \qquad f_k = \mu_k F_N$$

$$F_{\text{grav}} = G\frac{m_1 m_2}{r^2}, \quad \text{where} \quad G = 6.67 \times 10^{-11}\tfrac{\text{N}\cdot\text{m}^2}{\text{kg}^2} \qquad g = 9.80\tfrac{\text{m}}{\text{s}^2}$$

$$W = Fd\cos\theta \qquad F_{\text{spr}} = -kx$$

$$\text{KE} = \tfrac{1}{2}mv^2 \qquad \text{PE}_{\text{grav}} = mgh \qquad \text{PE}_{\text{spr}} = \tfrac{1}{2}kx^2 \qquad P = \tfrac{W}{t} \qquad P = Fv$$

The change in total mechanical energy is the work done by the non–conservative forces:

$$\Delta E = \Delta\text{PE} + \Delta\text{KE} = W_{\text{non-cons}}$$

$$\mathbf{p} = m\mathbf{v} \qquad \mathbf{I} \equiv \Delta\mathbf{p} \qquad \mathbf{F} = \frac{\Delta\mathbf{p}}{\Delta t} \quad \text{(Constant force)}$$

For a system with no net external force, the total momentum is conserved.

$$\omega = \omega_0 + \alpha t \qquad \theta = \theta_0 + \omega_0 t + \tfrac{1}{2}\alpha t^2 \qquad \omega^2 = \omega_0^2 + 2\alpha(\theta - \theta_0)$$

$$v = r\omega \qquad a_c = \frac{v^2}{r} = \omega^2 r \qquad a_T = r\alpha \qquad \omega = 2\pi f \qquad T = \frac{1}{f}$$

$$\tau = rF\sin\phi \qquad \tau_{\text{net}} = I\alpha \qquad \text{KE}_{\text{rot}} = \tfrac{1}{2}I\omega^2 \qquad I = \sum_{\text{mass pts}} mr^2$$

$$I_{\text{hoop}} = MR^2 \qquad I_{\text{disk}} = \tfrac{1}{2}MR^2 \qquad I_{\text{solid ball}} = \tfrac{2}{5}MR^2 \qquad I_{\text{rod,mid}} = \tfrac{1}{12}ML^2 \qquad I_{\text{rod,end}} = \tfrac{1}{3}ML^2$$

$$\text{KE}_{\text{roll, total}} = \tfrac{1}{2}Mv_{\text{cm}}^2 + \tfrac{1}{2}I\omega^2 \qquad v_{\text{cm}} = \omega r \qquad a_{\text{cm}} = \alpha r \qquad L = I\omega \qquad \tau = \frac{\Delta L}{\Delta t}$$

For a system with no net external *torque*, the total *angular* momentum is conserved.

$$\text{Statics:} \qquad \sum\mathbf{F} = \mathbf{0} \implies \left(\sum F_x = 0 \ \text{ and } \ \sum F_y = 0\right) \quad , \quad \sum_{\text{any axis}} \tau = 0$$

$$f = \frac{1}{T} \qquad \omega = 2\pi f \qquad f = \frac{1}{2\pi}\sqrt{\frac{k}{m}} \qquad f = \frac{1}{2\pi}\sqrt{\frac{g}{L}} \qquad v_{\max} = A\omega \qquad a_{\max} = A\omega^2$$

$$\lambda f = v \qquad v_{\text{str}} = \sqrt{\frac{F}{\left(\frac{m}{L}\right)}} \qquad \text{Use} \quad v_{\text{sound}} = 343\tfrac{\text{m}}{\text{s}} \qquad f_{\text{beat}} = |f_1 - f_2|$$

$$\rho = \frac{M}{V} \qquad \rho_{\text{H}_2\text{O}} = 1.0 \times 10^3\tfrac{\text{kg}}{\text{m}^3} \qquad \rho_{\text{Al}} = 2.70 \times 10^3\tfrac{\text{kg}}{\text{m}^3} \qquad \rho_{\text{Steel}} = 7.86 \times 10^3\tfrac{\text{kg}}{\text{m}^3}$$

$$1\,\text{atmosphere} = 1.013 \times 10^5\,\text{Pa} = 14.70\,\text{lb/in}^2 = 1.013\,\text{bar}$$

$$P_2 - P_1 = \rho gh \qquad P = P_{\text{atm}} + \rho gh \qquad P = P_{\text{gauge}} + P_{\text{atm}}$$

Archimedes' Princ: Buoyant force equals weight of displaced fluid.