Answer Key 2nd Exam 12/23/2021

1. Recall Lecture 7 - page 10:

the total mechanical energy E is conserved: $\Delta K = +200J \rightarrow$ $\Delta U = -200 J$.

2. Recall Lecture 8 - page 6 OR lecture 7 - page 6:

We can tackle the problem using the work-energy approach, and it's equivalent approach; Newton's 2nd law:

Work-Energy approach "scalar approach"

$$W_{F_{applied}} + W_{f_k} = \Delta K + \Delta U$$

$$-\mu_k mg \cos\theta \, d = \frac{mv^2}{2} - mgd\sin\theta$$

$$v = [2gd(\sin\theta - \mu_k \cos\theta)]^{1/2}$$

Newton's 2nd law approach "vector approach"

$$\sum \vec{F} = m\vec{a}$$

$$mg\sin\theta - \mu_k mg\cos\theta = ma$$

$$a = g(\sin\theta - \mu_k \cos\theta)$$

as a is constant, then

$$v^2 = 0 + 2ad.$$

3. As in the previous problem, you have two degrees of freedom on how to solve this one! Generally speaking, there is an advantage for the work-energy method over the force's approach (vector analysis).

1) $y_i = 0,\ y_f = y_{max} \Rightarrow$

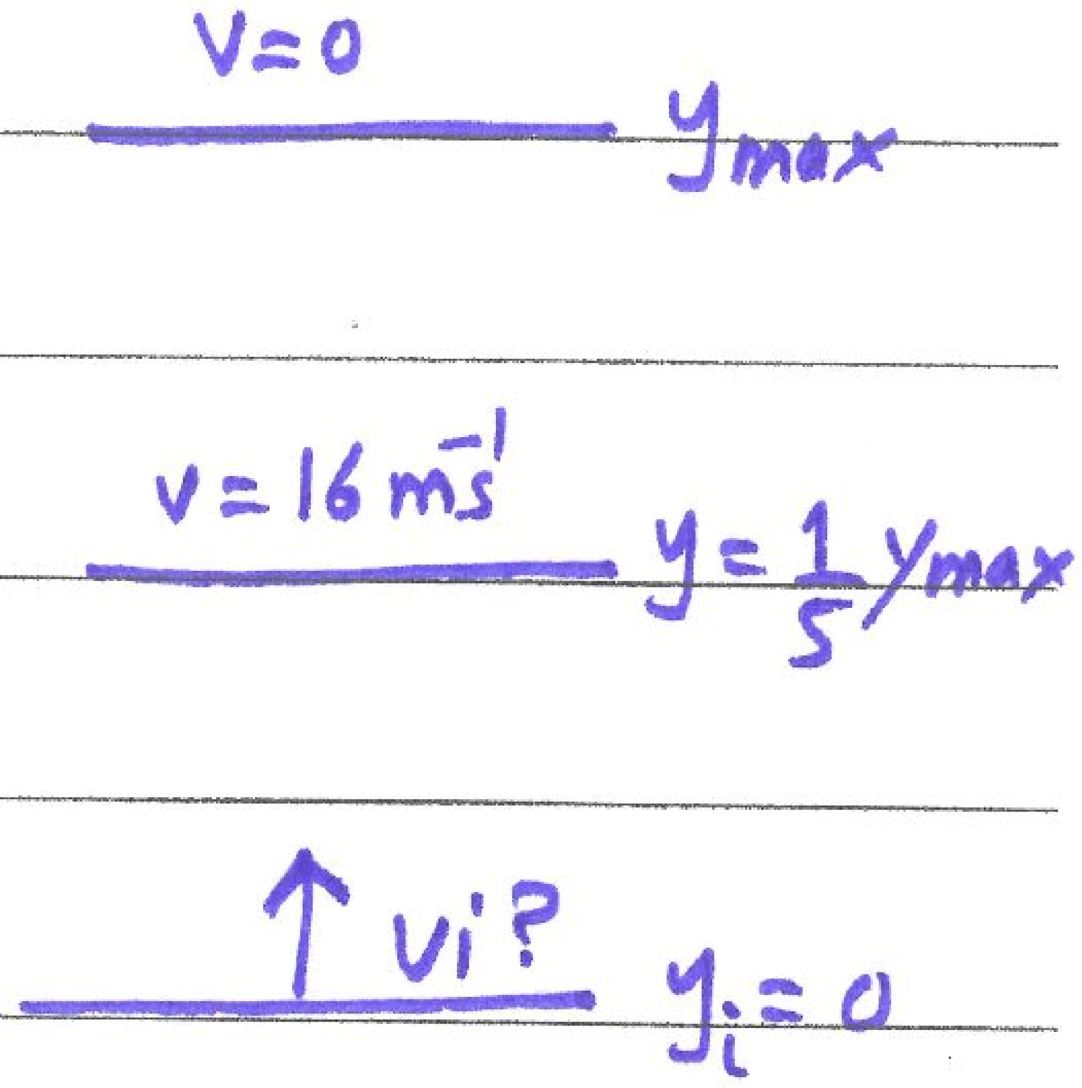
$$\frac{m v_i^2}{2} = m g\, y_{max} \rightarrow \underbrace{v_i^2 = 2 g\, y_{max}}$$

2) $y_i = 0,\ y_f = 1/5\ y_{max} \Rightarrow$

$$\frac{m v_i^2}{2} = \frac{m v^2}{2} + m g\, y_{max}/5$$

$$v_i^2 = v^2 + \frac{1}{5} * \underbrace{2 g\, y_{max}}$$

$$\therefore\ v_i^2 = v^2 + \frac{v_i^2}{5} \rightarrow v_i = \sqrt{\frac{5}{4}}\, v$$



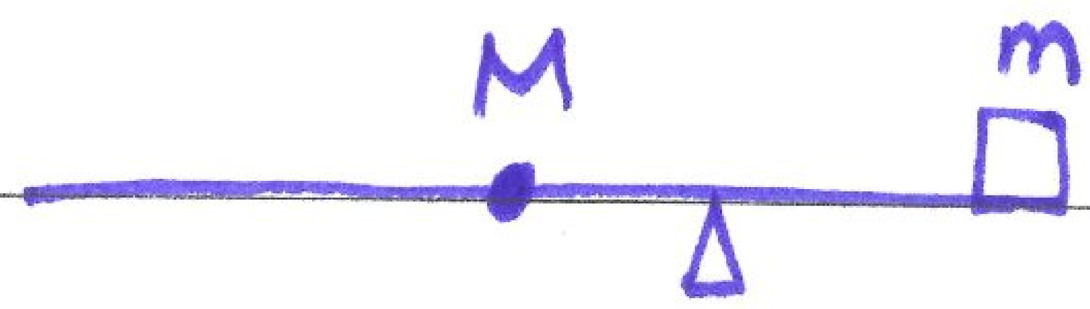
$\Rightarrow$ Force approach :→ freely falling object:-

recall lecture 3 - page 5:

$$t_{peak} = \frac{v_i}{g} \rightarrow y_{max} = \frac{v_i^2}{2g} \rightarrow v^2 = v_i^2 - 2g * \frac{1}{5} y_{max} \rightarrow v_i = \sqrt{\frac{5}{4}}\, v.$$

$\boxed{4}$ A clever selection of a pivot point is often the key to a quick solution. The "natural" selection in this problem is at the board's pivot itself.

One reads right off that



$$m g \frac{L}{4} = W \frac{L}{4}, \text{ where } W = M g$$

$$\Rightarrow W = m g.$$

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Student's Name (Arabic):.. **Student ID number** ....

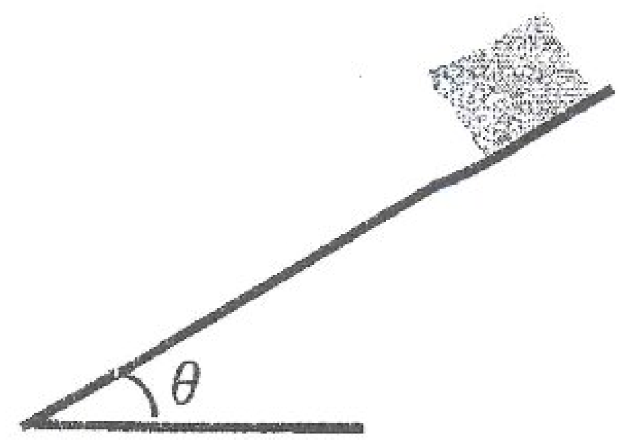
Lecturer's Name:.. **Section and time of lecture** ....

Take $g = 9.8$ **m/s^2**, form number 1571, 2nd Exam, Time: 50 minutes Date: Dec/23/2021

Q1) A stone is released from rest at a height h above the ground's surface. Just before it hits the ground its kinetic energy is 200 J. Ignoring air resistance, the change in the potential energy of this stone is (in J) is:

A) 200 B) 0 C) -200 D) 100 E) -100

Q2) The figure shows a box of mass M = 4.0 kg, which slides down a rough inclined plane that makes an angle $\theta = 30°$ with the horizontal. If the object starts from rest and the coefficient of kinetic friction is $\mu_k = 0.2$, find the speed of the box (in m/s) when it has moved 3.0 m down the inclined plane.

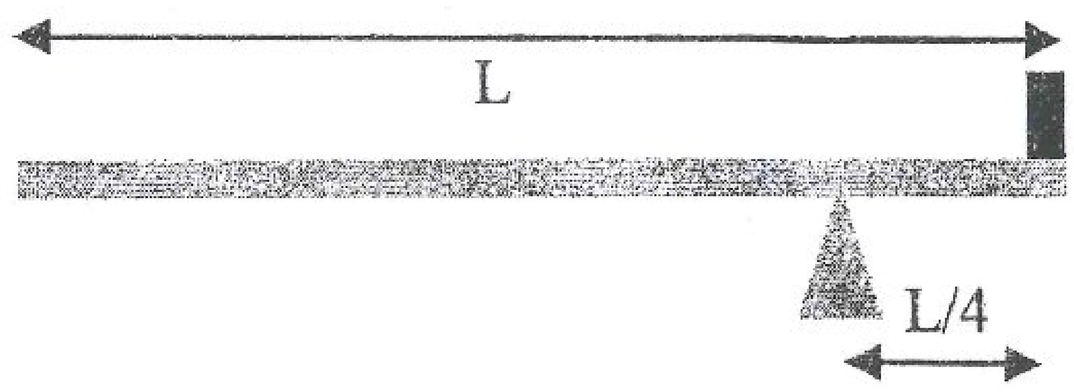


A) 4.4 B) 6.3 C) 7.1 D) 3.1 E) 5.3

Q3) A ball is thrown vertically upwards with an initial speed v_i. When it has reached a height of one-fifth of its maximum height, its speed is 16.0 m/s upwards. The initial speed (v_i) of the ball (in m/s) is: (Ignore air resistance)

A) 39.2 B) 25.1 C) 27.7 D) 17.9 E) 20.6

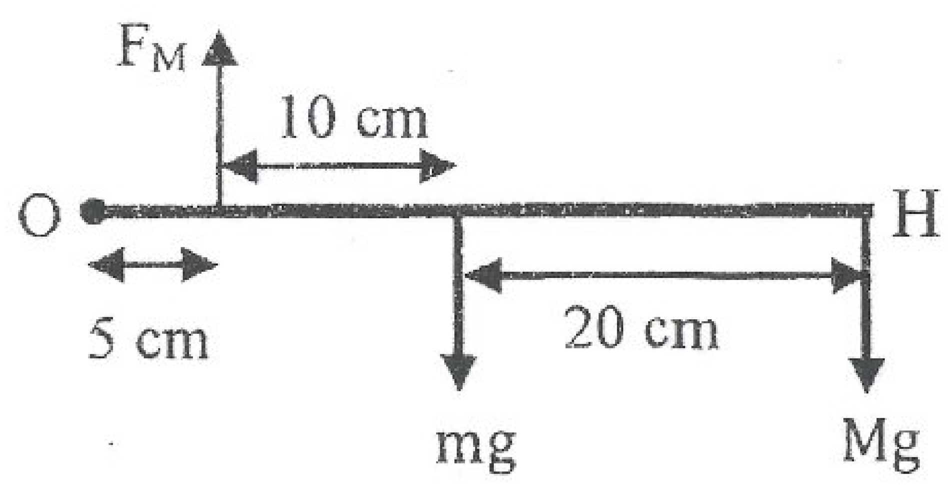
Q4) A 40-kg box is placed at the end of a uniform board of length L and mass M. The pivot is placed a distance L/4 from the end of the board as shown. If the board is in static equilibrium, then the weight of the board (in N) is:



A) 200 B) 392 C) 120

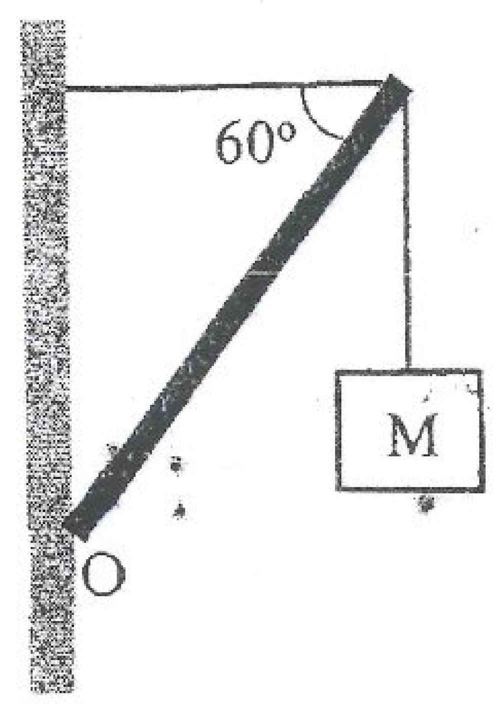
D) 196 E) 784

Q5) The figure represents a forearm of mass m in a horizontal position as shown. The elbow joint, O, is 5 cm from the force exerted by the biceps muscle, F_M. When a mass M is held in the hand at the position H, the forearm is in static equilibrium. If $F_M = 185$ N, and M = 2.0 kg, then the mass m (in kg) is:



A) 1.9 B) 2.1 C) 0.5
D) 1.1 E) 1.6

Q6) A 25.0-kg uniform beam is attached to the wall by a hinge at point O. It is held in static equilibrium by connecting it to a 1.5 m horizontal rope which is tied to the wall. A mass M = 18.0 kg is suspended in equilibrium from the beam using another vertical rope as shown. The magnitude of the horizontal component of the hinge force (in N) that acts on the beam at point O is:

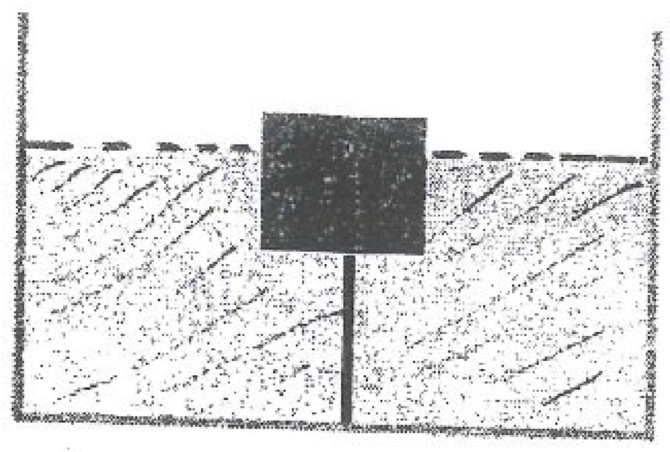


A) 172.6 B) 297.9 C) 99.6 D) 122.1 E) 23.5

Q7) Consider a plastic cube of side length 20 cm and density of 0.5 grams/cm^3. If you push the cube **until it is completely submerged under water** (of density of 1.0 grams/cm^3), and continue to push the cube deeper below the water surface, which of the following statements is correct?

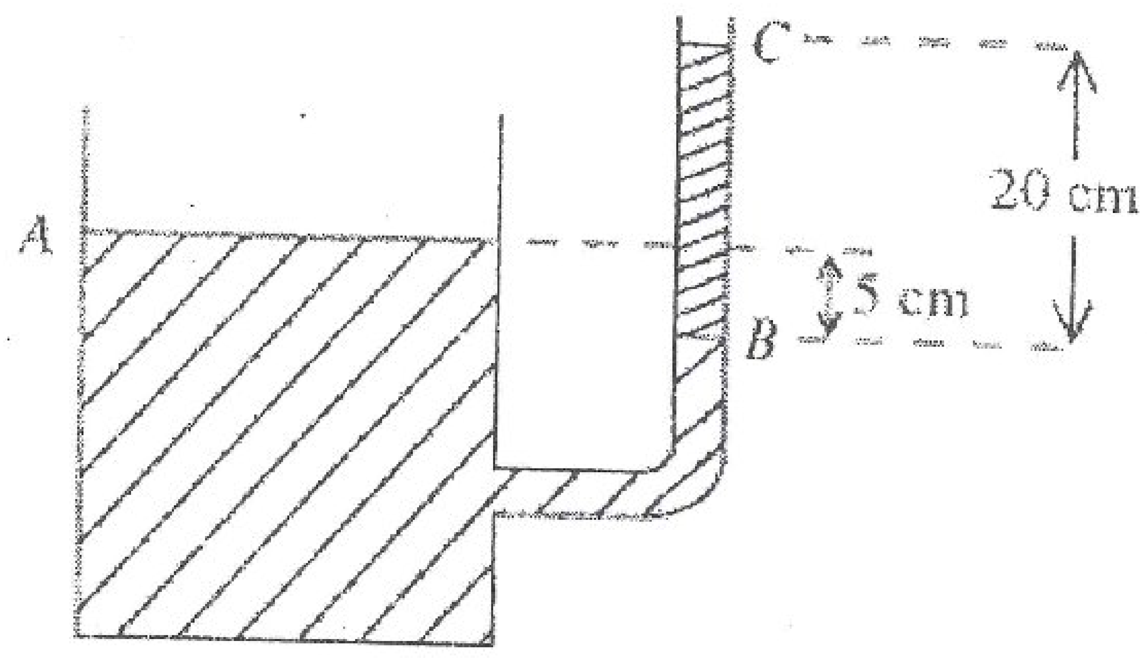
A) The weight of the cube is greater than the buoyant force acting on it.
B) If you remove your force that acts on the cube, it will always move down and will never move up.
C) The buoyant force acting on the cube becomes larger as the cube moves deeper below the water surface.
D) The buoyant force acting on the cube remains constant as the cube moves deeper below the water surface.
E) The buoyant force that acts on the cube when it is fully under water depends on the density of the cube.

Q8) The figure shows a box with exactly 0.8 of its volume submerged in water. If the volume of the box is 0.001 m^3, and $\rho_O = 0.2\,\rho_W$, where ρ_O is the density of the box, and $\rho_W = 1000$ kg/m^3 is the density of the water, then the tension (in N) in the string is:



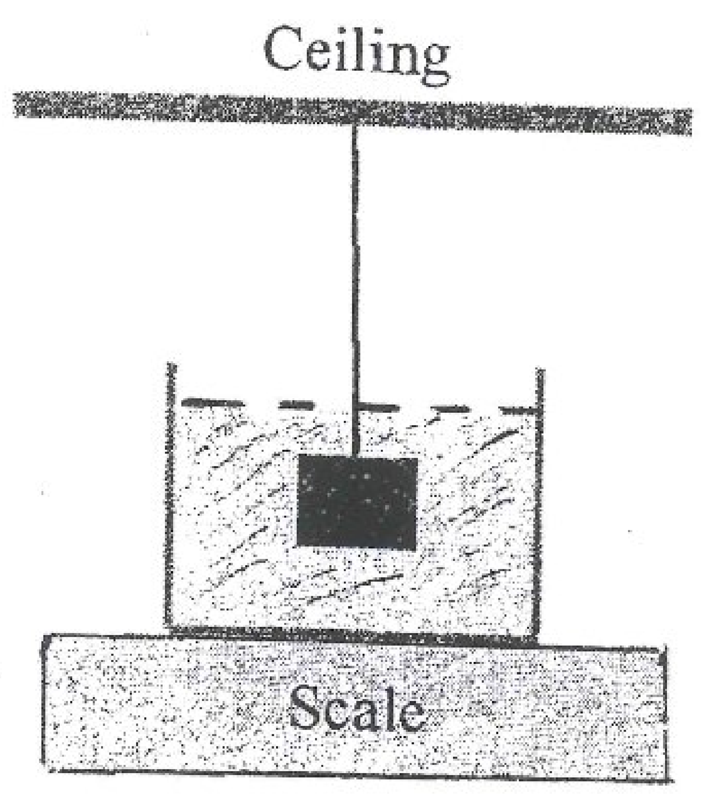
A) 0.2 B) 7.8 C) 0 D) 9.8 E) 5.9

Q9) Mercury reaches level A in an open, wide, vertical container and reaches level B in an open, narrow, vertical tube. The wide container and the narrow tube are connected through a hole of inner radius 32.00 mm, as shown. Level A is 5.0 cm higher than level B. The mercury supports a 20.0 cm high column of unknown liquid, between levels B and C. The density (in kg/m^3) of the unknown liquid is: (density of mercury is 13600 kg/m^3)



A) 54400 B) 3400 C) 13600
D) 10200 E) 6800

Q10) A 1.00-kg beaker containing 2.00 kg of oil (density=916 kg/m^3) rests on a scale. A 3.00-kg block of iron (density=7870 kg/m^3) is suspended in equilibrium from a rope and is completely submerged in the oil. What is the reading (in N) of the scale?



A) 58.8 B) 29.4 C) 32.8
D) 26.0 E) 3.4

YOU MUST write the SYMBOLE for each correct answer in the TABLE below. IF you don't you WILL LOOSE MARKS. Write in CAPITAL letters.

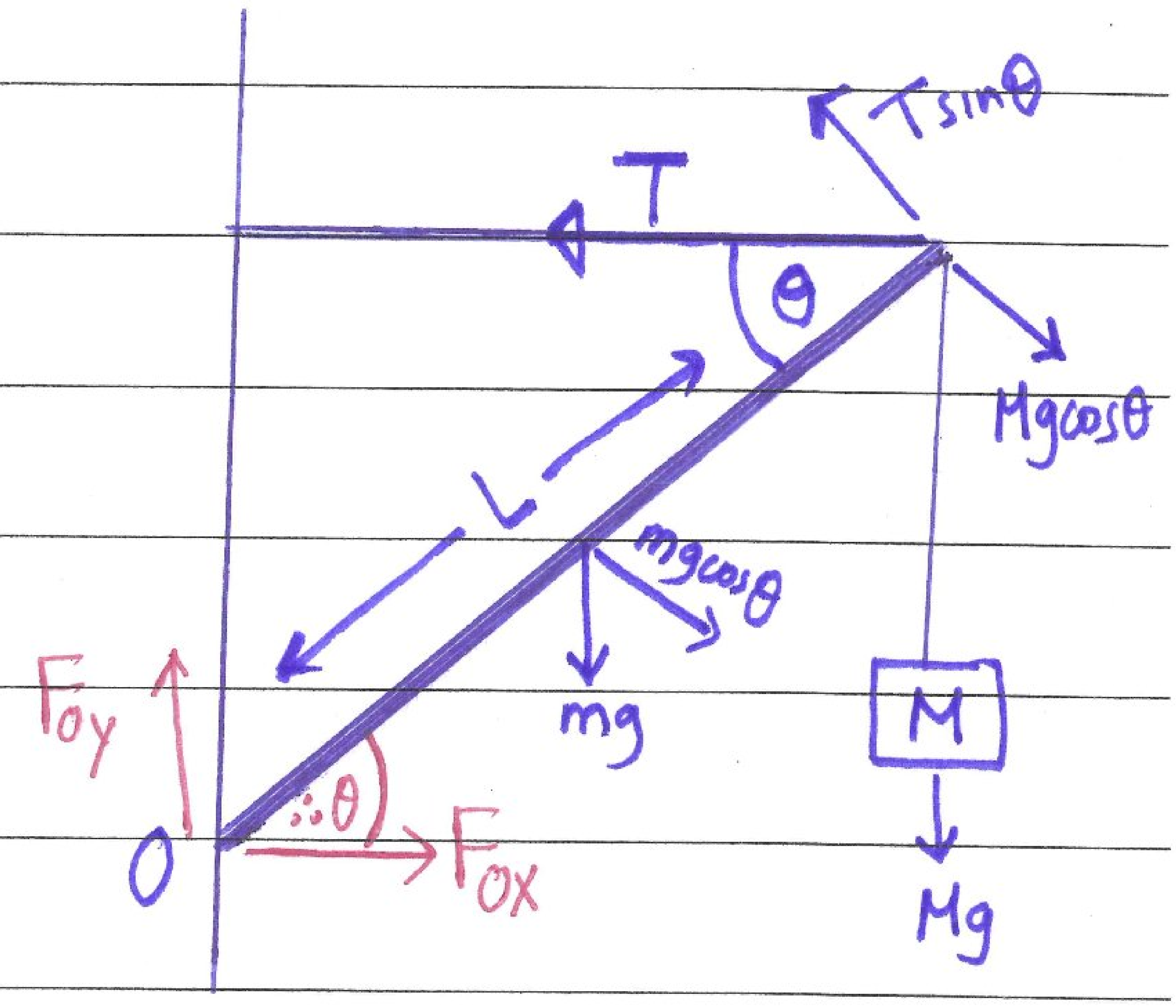
Q1	Q2	Q3	Q4	Q5	Q6	Q7	Q8	Q9	Q10
C	A	D	B	E	A	D	E	B	C

5) When an unknown force is present in a problem; the joint force in our case, one can select the point where the force acts as the pivot point — O in our case. Then, the joint force will not enter into the torque equation because it has a lever arm of length zero.

Recall Lecture 10 - page 3 & lecture 11 - page 1.

$F_M * 0.05 = mg * 0.15 + Mg * 0.35$ and solve for m.

6)



We know right off what Fox and Foy are:

$F_{ox} = T$ — (1)

$F_{oy} = (m+M)g$ — (2)

Both masses, m and M, are given, thus F_{oy} is known.

Technically, the problem is about finding T.

The torque of about O reads:-

$(T\sin\theta)(L) = (Mg\cos\theta)(L) + (mg\cos\theta)(L/2)$.

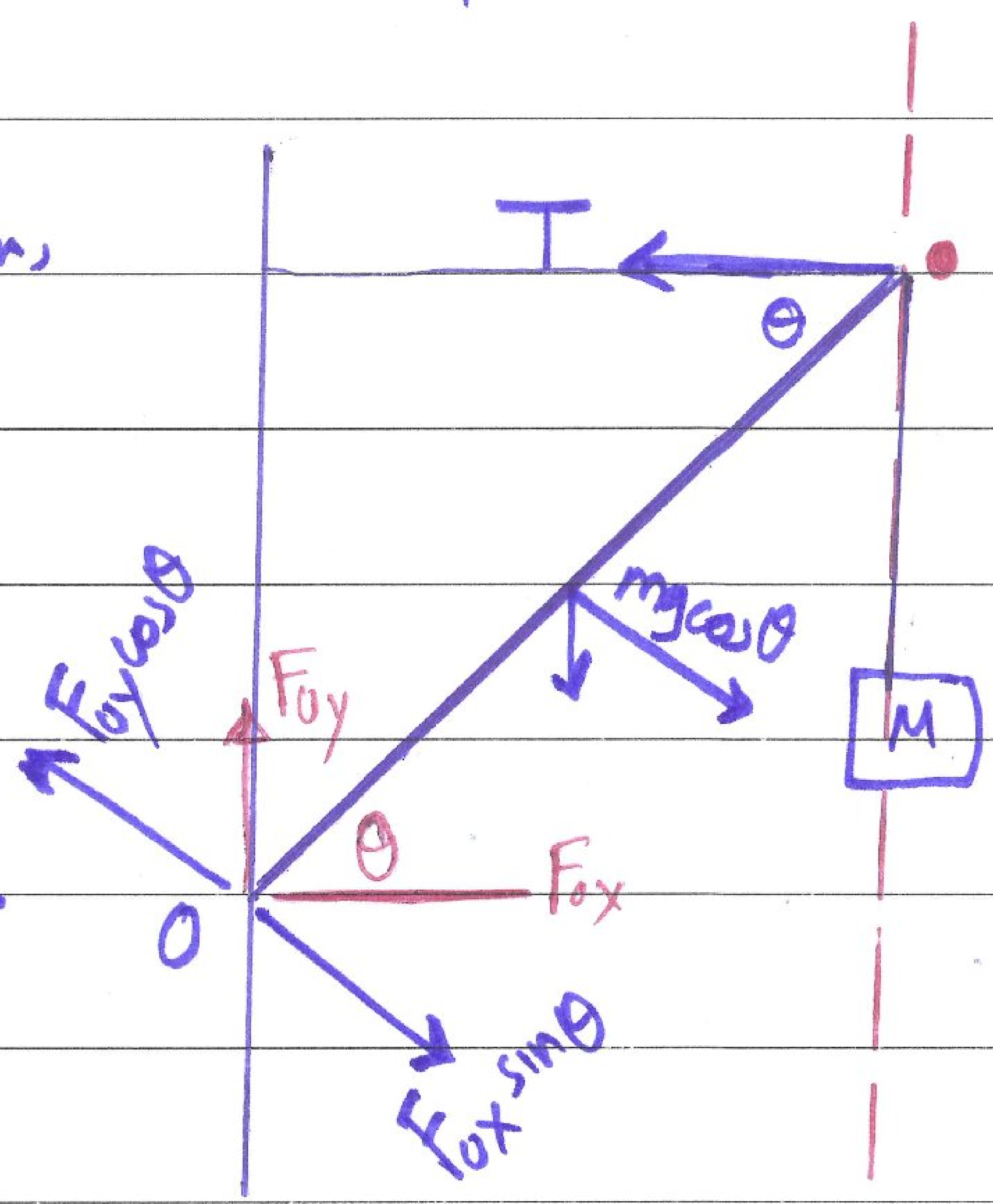
Hmm.... this explains why L is not given in the stem of the question: $T = \left(\frac{m}{2} + M\right)g * (\cot\theta)$

⇒ For the numerical values given in the question, one finds $F_{oy} = 421.4\,N$, $F_{ox} = T = 172.6\,N$.

⇒ The magnitude of the hinge force $= \sqrt{(F_{ox})^2 + (F_{oy})^2}$.

⇒ Notice that the length of the horizontal rope (1.5m) is irrelevant to our calculations!

⇒ Let's validate our calculations by choosing the point ● as a pivot point.



$$(mg\cos\theta)\frac{L}{2} + (F_{ox}\sin\theta)L = (F_{oy}\cos\theta)L$$

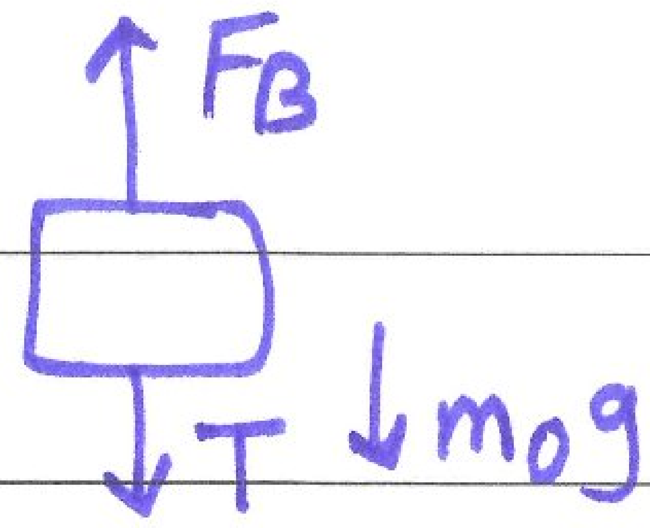
$$\Rightarrow F_{ox} = \left(F_{oy} - \frac{mg}{2}\right) * (\cot\theta).$$

$\boxed{7}$ Recall exercise D - lecture 14 - page 23.

$F_B = m_f g = \rho_f * V_f * g$, for totally submerged object $V_f = V_0$

$\therefore F_B = \rho_f * g * V_0 =$ constant.

- You should rationalize why the other options are incorrect.



$\boxed{8}$ Let m_0 = mass of the object,

m_W = " " water, then

$F_B = T + m_0 g \rightarrow T = m_W g - m_0 g = (m_W - m_0) g$.

$T = [\rho_W * (0.8 V_0) - \rho_0 * V_0] g$, $\rho_0 = (0.2) * \rho_W \Rightarrow$

$T = \rho_W * V_0 * (0.6) * g$, $\rho_W * V_0 = 1$

$\therefore T = (0.6) g$.

$\boxed{9}$ Recall assignment #3 - problems 20 & 24.

$P_B = P_A + \rho_{Hg} g * 0.05$ —— (1)

$P_B = P_C + \rho_f g * 0.20$ —— (2)

$P_A = P_C = P_{atm}$

The left-hand sides of the two equations are equal, thus,

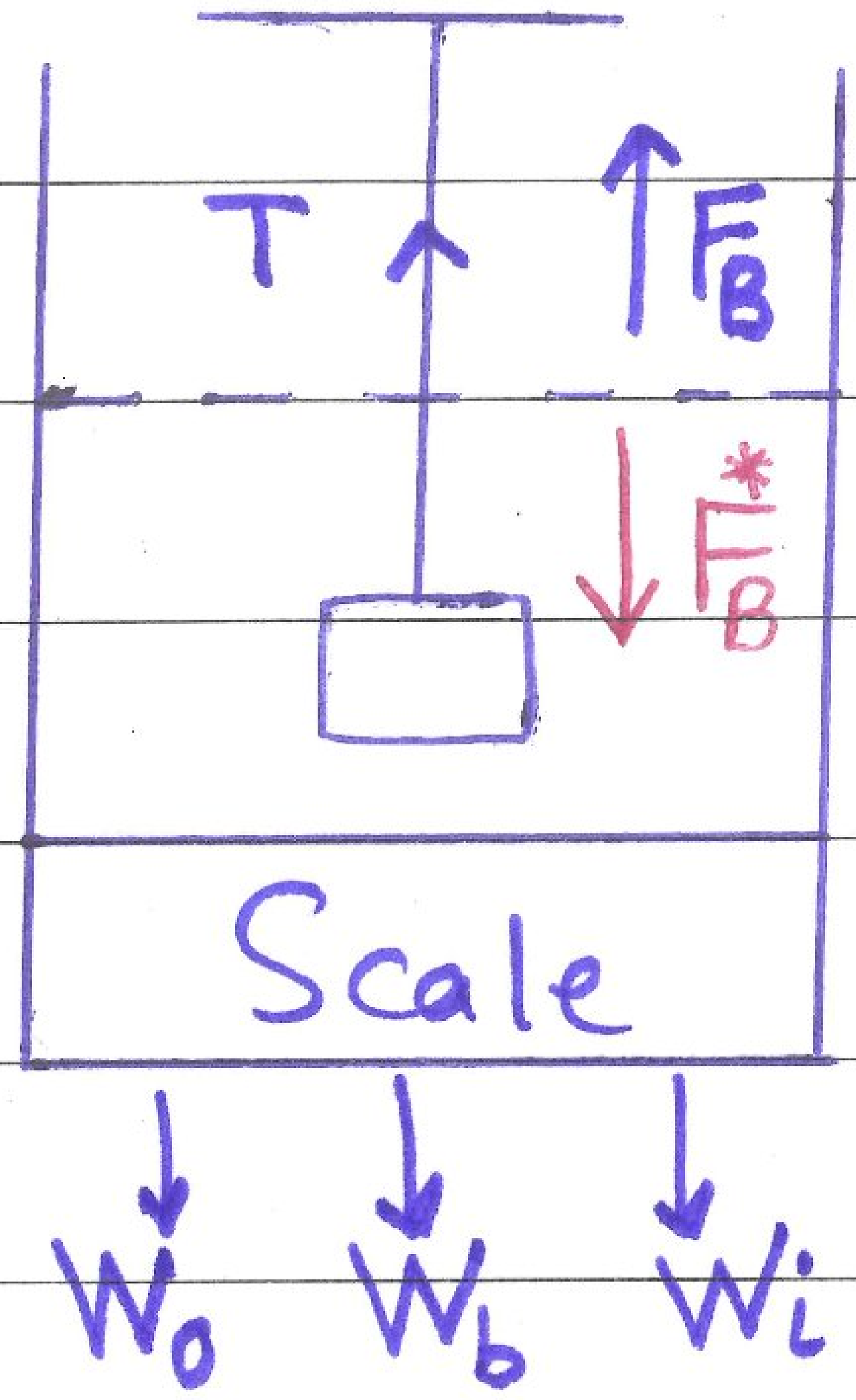
$P_A + \rho_{Hg} g * 0.05 = P_C + \rho_f g * 0.20$ → solve for ρ_f.

$\rho_f = \left(\frac{0.05}{0.20}\right) \rho_{Hg} = \frac{1}{4} * \rho_{Hg}$.

• By making an educated guess, one can safely eliminate choice A and choice C, and increase the probability of getting the correct answer.

10

- Let W_0 = weight of oil
  W_b = weight of beaker
  W_i = weight of iron



- The weight of iron is supported by the tension in the rope and does not affect the reading on the scale.

Recall eq (2) - lecture 14 - page 27 : $T = W_i - F_B$:
the reading of T "apparent" is less than the "real" weight.

- If the oil exerts an upward buoyant force on the iron block, by Newton's 3rd law the block exerts a downward force F_B^* on the oil that is equal in magnitude.
- Thus the reading on the scale can be determined by considering the forces acting on the oil, W_0 and F_B^*, the weight of the beaker, and the upward force from the scale, which sum to zero because the whole system is in equilibrium.

$$\therefore F_{scale} = W_0 + W_b + F_B^* .$$
$$= 3g + \left(\frac{\rho_0}{\rho_i}\right) W_i$$

$$F_B^* = \rho_0 V_i g = \rho_0 \left[\frac{m_i}{\rho_i}\right] g$$
$$= \left(\frac{\rho_0}{\rho_i}\right) W_i$$

6/6