Part I: Choose the best answer and write your choice on the space provided in capital letter! (9%)

A 1. If $\mathbf{A} = (2m)\mathbf{i} - (3m)\mathbf{j}$ and $\mathbf{B} = (1m)\mathbf{i} - (2m)\mathbf{j}$, then $\mathbf{A} - 2\mathbf{B} = ?$

A. $(1m)\mathbf{j}$ B. $(-1m)\mathbf{j}$ C. $(4m)\mathbf{i}-(7m)\mathbf{j}$ D. $(4m)\mathbf{i}+(1m)\mathbf{j}$

C 2. Four objects are situated on xy-plane as follows: a 1 kg object at the origin, 2kg object at +1cm on the x-axis, a 3kg object at +2cm on the y-axis, and a 4kg object at (+1cm, -2cm). Where is the center of mass of these objects?

A.(1,0)cm B. (0.6, 1.4)cm C.(0.6, -0.2)cm D.(0.6,0.2) cm

B 3. The "reaction" force does not cancel the "action" force because:

A. The action force is greater than the reaction force
B. They are on different bodies
C. They are in the same direction
D. The reaction force exists only after the action force is removed

D 4. Which one of the following is true about fluid static?

A. All points at same level in a fluid have same pressure.
B. Fluid pressure increases with increase in the depth of the fluid.
C. Fluid pressure does not depend on the shape of the container.
D. All

B 5. The small piston of a hydraulic lift has an area of 0.2 m^2. A car weighing 1.2×10^4 N sits o a rack mounted on the large piston. The large piston has an area of 0.9 m^2. How large forc must be applied to the small piston to support the car?

A. 2.7×10^5 N B. 2.7×10^3 N C. 7×10^2 N D. 3×10^4 N

B 6. A bead slides without friction around a loop (see fig). The bead is released from a height h = 3.5 What is its speed at point A?

A. $\sqrt{3gR}$ m/s B. $\sqrt{5gR}$ m/s C. $\sqrt{7gR}$ m/s D. 0 m/s



Part II: Give short and precise answer for the following questions (5%)

1. State the three Kepler's laws of planetary motion. (3pts)

① Kepler's 1st law: "The orbit of each planet in the solar system is an ellipse. The sun will be the one focus"

② Kepler's 2nd law "The radius vector connecting the center of the sun and the planet sweeps out equal areas in equal interval of time"

③ Kepler's 3rd law "The square of the orbital period of a planet is proportional to the cubic of the average distance b/w the center of the planet"

$$\frac{T^2}{r^3} = \text{constant} \Rightarrow \left(\frac{T_1}{T_2}\right)^2 = \left(\frac{r_1}{r_2}\right)^3$$

2. State Archimedes' Principle (2 pts)

~~The amount of mass submerged is equal to the~~

Buoyant force of an ob

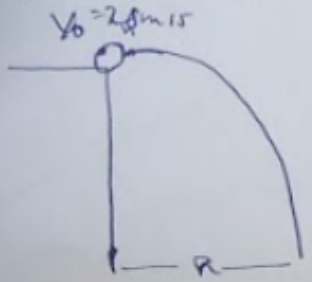
Part III: Solve the following problems by showing all the necessary steps (16%)

1. A ball is tossed from an upper-story window of a building. The ball is given an initial velocity of 25 m/s at an angle of 53^0 above the horizontal. It strikes the ground 3 seconds later. Use: $g = 10m/s^2$ (4pt)

   a) How far horizontally from the base of the building does the ball strike the ground?

   b) Find the height from which the ball was thrown.

   c) With what velocity it strikes the ground?



(a) find Range

from kinematic equation

$d = Vt$

but Range is the horizontal distance

so

$d_x = V_x t$ ⇒ and V_x is $V\cos\theta$

and d_y = Range

$R = V\cos\theta\, t$ ⇒ and velocity is constant along horizontal

$R = 25 \times \cos 53 \times 3$

$= 25 \times 0.6 \times 3 =$ 45 m

(b) height?

from third acceleration equation

$d = V_0 t + \frac{1}{2} a t^2$

$d_y = V_{y0} t + \frac{1}{2} a_y t^2$ ⇒ as it is simple projectile so it has initial vertical velocity

$V_{oy} = 0$ bic on maximum height it velocity along y (vertical direction) is 0 that means that is no vertical motion there is only horizontal motion

⇒ $d_y = \frac{1}{2} a_y t^2$ ⇒ in vertical

$a_y = g$

$h = \frac{1}{2} g t^2$

$h = \frac{1}{2} 10 \times 9 =$ 45 m

(c) $V = V_0 + at$

$V = 25 + gt$.

$= 25 + 10(3)$

$= 55$ m/s

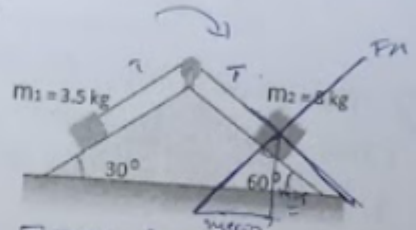
$V = \sqrt{V_x^2 + V_y^2}$

2. Two blocks of Masses m_1=3.5 kg and m_2 = 8 kg are connected by a massless string that passes over a frictionless pulley as shown in the figure below. The coefficient of friction between the incline and the block is 0.25. Using $g = 10\ m/s^2$, find (4pts)

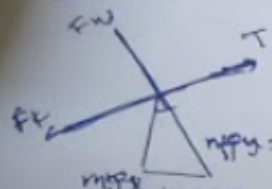
a) The magnitude of the acceleration of each block $a = 2.93$

b) The tension in the string. $T =$

c) Determine the direction of the acceleration.



FBD for m_1



A/A

$\Sigma F_x = ma = T - m_1g\sin\theta_1 - f_k = m_1a$

$T - m_1g\sin\theta_1 - f_k = m_1a$ ---(1)

$\Sigma F_y = 0 = F_N - m_1g\cos\theta_1$

$f_k = \mu_k F_N \Rightarrow F_N = m_1g\cos\theta_1$

$T - m_1g\sin\theta_1 - \mu_k m_1g\cos\theta_1 = m_1a$ ---(1)

$a = \theta = ?$

$+ T - m_1g\sin\theta_1 - \mu_k m_1g\cos\theta_1 = m_1a$

$m_2g\sin\theta_2 - T = \mu_k m_2g\cos\theta_2 = m_2a$

$-m_2g\sin\theta_2 - m_1g\sin\theta_1 - \mu_k m_1g\cos\theta_1 - \mu_k m_2g\cos\theta_2 = a(m_1+m_2)$

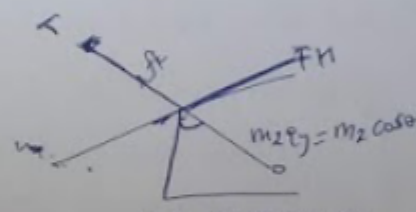
$a = \dfrac{m_2g\sin\theta_2 - m_1g\sin\theta_1 - \mu_k m_1g\cos\theta_1 - \mu_k m_2g\cos\theta_2}{m_1+m_2}$

$= \dfrac{8\times10\sin60 - 3.5\times10\sin30 - 0.25(3.5)(10)\cos30 - 0.25(8)(10)\cos60}{3.5+8}$

$= \dfrac{(8\times10\times0.86) - (3.5\times10\times0.5) - (0.25\times3.5\times10\times0.86) - (0.25\times8\times10\times0.5)}{11.5}$

$= \dfrac{68.8 - 17.5 - 7.525 - 10}{11.5} = \dfrac{33.775}{11.5} = 2.93\ m/s^2$

FBD for m_2



$\Sigma F_x = ma = mg_x - T - f_k = m_2a$

$= m_2g\sin\theta_2 - T - \mu_k F_N = m_2a$ (2)

$\Sigma F_y = 0 = F_N - mg\cos\theta_2 = 0$

$F_N = m_2g\cos\theta_2 =$

$m_2g\sin\theta_2 - T_B - \mu_k m_2g\cos\theta_2 = m_2a$

On the back page

3. A 0.5kg sphere moving with a velocity $(2\mathbf{i} - 3\mathbf{j} + \mathbf{k})$ m/s strikes another sphere of mass 1.5kg moving with a velocity $(\mathbf{i} + 2\mathbf{j} - 3\mathbf{k})$ m/s. (4pts)

a) If the velocity of the 0.5kg sphere after the collision is $(-\mathbf{i} + 3\mathbf{j} - 8\mathbf{k})$ m/s, find the final velocity of the 1.5kg sphere

b) Identify the kind of collision (elastic, inelastic, or perfectly inelastic).

let $m_1 = 0.5$ kg

$m_2 = 1.5$ kg

(a) $m_1 v_{1i}\bar{i} + m_2 v_{2i}\bar{i} = m_1 v_{1f} + m_2 v_{2f}$

$0.5(2\bar{i} - 3\bar{j} + \bar{k}) + 1.5(\bar{i} + 2\bar{j} - 3\bar{k}) = 0.5(-\bar{i} + 3\bar{j} - 8\bar{k}) + 1.5 v_{2f}$

$\bar{i} - 1.5\bar{j} + 0.5\bar{k} + 1.5\bar{i} + 3\bar{j} - 4.5\bar{k} = -0.5\bar{i} + 1.5\bar{j} - 4\bar{k} + 1.5 v_{2f}$

$2.5\bar{i} + 1.5\bar{j} - 4\bar{k} = -0.5\bar{i} + 1.5\bar{j} - 4\bar{k} + 1.5 v_{2f}$

$2.5\bar{i} + 1.5\bar{j} - 4\bar{k} - (-0.5\bar{i} + 1.5\bar{j} - 4\bar{k}) = 1.5 v_{2f}$

$2.5\bar{i} + 1.5\bar{j} - 4\bar{k} + 0.5\bar{i} - 1.5\bar{j} + 4\bar{k} = 1.5 v_{2f}$

$\frac{3\bar{i}}{1.5} = \frac{1.5 v_{2f}}{1.5}$, $v_{2f} = 2\bar{i}$ m/s A/A

(b) ~~Elastic collision~~. (Inelastic collision)

$\Delta KE = \Delta KE$

$\frac{1}{2} m_1 v_{1i}^2 + \frac{1}{2} m_2 v_{2i}^2 = \frac{1}{2} m_1 v_{1f}^2 + \frac{1}{2} m_2 v_{2f}^2$

$0.25(4\bar{i} + 9\bar{j} + \bar{k}) + 0.7(\bar{i} + 4\bar{j} + 9\bar{k}) = 0.25(\bar{i} + 9\bar{j} + 64\bar{k}) + 0.7(d\bar{j})$

$\bar{i} + 2.25\bar{j} + 0.25\bar{k} + 0.7\bar{i} + 3\bar{j} + 6.3\bar{k} = 0.25\bar{i} + 2.25\bar{j} + 16\bar{k} + 3.5$

$0.25(d) + 0.7j(d) = 0.25(d) + 0.7s(d)$

$3.5 + 10.5 = 0.7s + 3$

$d\bar{j} = 21.5\bar{j}$

4. Water circulates throughout a house in a hot water heating system. If the water is pumped at a speed of 0.5m/s through a 4cm diameter pipe in the basement under a pressure of 3.03×10^5Pa, what will be the velocity and pressure in a 2.6cm diameter pipe on the second floor 5m above? (4pts)

$V_1 = 0.5 m/s$

$A_1 = \pi r^2 \quad r = 2cm = 0.02$

$P_1 = 3.03 \times 10^5 Pa$

$r_2 = 1.3 \times 10^{-3} m$

$A_1 = \pi r^2$

$\pi (2 \times 10^{-2} m)^2$

$A_2 = \pi r^2$

$A_1 V_1 = A_2 V_2$ Equation of continuity

$V_2 = 7.43 \times 10^{-10}$

$3.03 \times 10^5 Pa + 120 Pa - P_2 + 720 Pa$

$P_2 = 303000 Pa - 273,293$

$P_2 = 29,707 Pa$

Bernoulli's equation

$A_1 = \pi r_1^2 = 4 \times 10^{-4} \pi$

$A_2 = \pi \cdot r_2 = 1.6 \times 10^{-3} \pi$

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