Arts & Science 2D06

Quiz #3 2012 Nov 1 **Name:** Solutions

NB: Mark values are given in brackets [ ] beside each problem. Write all your answers on the quiz paper. No books or notes allowed. Time to write quiz: 50 minutes.

Solution for quadratic equation: $x = (-b \pm \sqrt{b^2 - 4ac})/2a$

centripetal $a_c = v^2/r$ linear K.E. $= (1/2)mv^2$ Rotational K.E. $= (1/2)I\omega^2$

Energy conservation $E = K + U$ Gravitational force: $F_g = GMm/r^2$

Elastic collisions, target m_2 stationary: $v_1 = \frac{(m_1 - m_2)}{(m_1 + m_2)} u_1$, $v_2 = \frac{2m_1}{(m_1 + m_2)} u_1$

---

1. [3] Suppose an astronaut finds herself halfway between the moon and the earth. The net gravitational force on the astronaut due to the two objects is: (Explain/derive your answer in the space provided.)

a) directed towards the moon.
(b) directed towards the earth.
c) zero.
d) more information is required.

Since $M_{earth} > M_{moon}$,

$(F_g)_{earth} > (F_g)_{moon}$

$\therefore \Sigma F$ is towards Earth.

2. [3] Two friends are sitting on opposite ends of a canoe, which is initially stationary relative to the lake. One person throws a heavy ball to the other, who catches it. After the ball is caught, the canoe will be: (ignore friction between the water and the canoe)

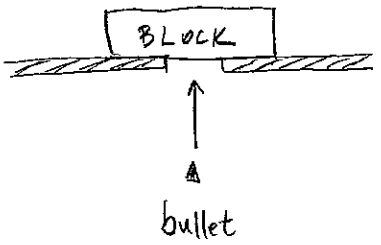
a) moving to the left.
b) moving to the right.
(c) not moving.
d) rotating.

3. [4] A hollow sphere ($I = (2/3)MR^2$) and a solid sphere ($I = (2/5)MR^2$) have the same mass and radius. If they are rolling without slipping along a horizontal surface with the same speed, then which object has more kinetic energy?

$$K = \frac{1}{2}Mv^2 + \frac{1}{2}I\omega^2 = \frac{1}{2}Mv^2 + \frac{1}{2}I\left(\frac{v}{R}\right)^2$$

$\therefore$ object with larger moment of inertia has more kinetic energy $\rightarrow$ ~~Solid~~ sphere hollow

4. [5] A 2.4-kg block is at rest on a table, as shown in the figure below. A 15-g bullet traveling at 290 m/s strikes the block directly from below. If the bullet remains embedded in the block, calculate how high the block will jump after it is struck.



$$P_0 = m_b \cdot v_b = 4.35 \text{ kg} \cdot \text{m/s}$$

$$P_f = (m_b + m_{block}) v_f = 2.415\, v_f$$

$$\therefore \quad v_f = \frac{4.35}{2.415} = 1.8 \text{ m/s}$$

for the jump: $E_0 = E_f$

$$\frac{1}{2}(m_b + m_{block}) v_f^2 = (m_b + m_{block}) gh$$

$$h = \frac{v_f^2}{2g} = 0.16 \text{ m}$$

5. [5] If the Moon were moved to twice the distance from Earth's centre than at present, calculate the amount of time it would take for the Moon to go once around the earth. (The current orbital period of the Moon is four weeks.)

· @ present : $T_0 = \frac{2\pi R_0}{V_0}$

· after move : $R_f = 2R_0$

and $\frac{GM_{EM}}{R^2} = \frac{mv^2}{R} \Rightarrow V_0 = \sqrt{\frac{GM}{R}} \rightarrow V_f = \sqrt{\frac{GM}{2R}} = \frac{V_0}{\sqrt{2}}$

$\therefore T_f = \frac{2\pi(2R_0)}{\frac{V_0}{\sqrt{2}}} = 2\sqrt{2}\,T_0 \approx 11$ weeks.

[20] total marks