PHYSICS 241 – Computational Mechanics – Fall 2011

Quiz 2 –

You can (and should) bring a scientific calculator. No other reference material is allowed.

1) [10] Two masses are connected only by a spring and subject to no forces but the spring force. Is angular momentum of the two mass system conserved? Why, or why not? **YES. THE FORCE EXERTED BY THE SPRING IS ALONG LINE JOINING THE MASSES, THUS RxF IS IDENTICALLY ZERO EVERYWHERE AND THE INTERNAL TORQUES ARE ZERO, SO dL/dt = 0**

3 points for "NO" with an explanation
6 points for "Yes" with no explanation
8/9 points for "Yes" with a partial explanation. Saying "external forces = 0" is not an explanation. Saying the word "torque" helped. Saying "central force" or "analagous to gravity" helped.

2) There are three particles: $m_1 = 1\ \text{kg},\ m_2 = 2\ \text{kg},\ m_3 = 3\ \text{kg}.$
The particles have positions as a function of time as follows:
$\vec{r}_1(t) = (1000\,\hat{i} + 1000\,\hat{j} + 50t\,\hat{k})$ meters.
$\vec{r}_2(t) = (10t^2\,\hat{i} + 20t^2\,\hat{j} + 30t^2\,\hat{k})$ m.
$\vec{r}_3(t) = (5t^3\,\hat{i} + 5t^3\,\hat{j} - 5t^3\,\hat{k})$ m.

I recommend making a table of velocities to keep this problem organized.

[**10]** (a) What is the velocity vector of the center of mass at t=2 seconds?
$\mathbf{\vec{v}_{cm} = (43.33\,\hat{i} + 56.67\,\hat{j} + 18.33\,\hat{k})\ m/s.}$
Calculate r_cm instead of v_cm (3/10) Correct approach but calculation error -2 or -3. Incorrect approach to v_cm calculation -5 to -7.

[10] (b) What is the kinetic energy of the center of mass of the three-particle system (at t=2)?
16300 Joules, Giving KE in components -5.

3a) [10] What is the orbital period of a binary star composed of two objects the mass of Earth's sun that are separated by 150 million km? Provide a number by any means at your disposal (for example, a memorized formula). [You may assume the separation between the stars is constant]. $M_{sun} = 2 \times 10^{30}$ kg.
Since the stars are same distance as Earth from Sun and their mass is same as sun, the Period is 1 year / sqrt 7 = 22.3 million seconds.

3b) [15] If you did not derive your answer to "a" from first principles, do so now. You may use the reduced mass method or the method that accounts for center of mass – so long as you do it correctly. You do not have to derive the reduced mass method (if you use it). **Writing some relevant formulae but not putting it together, -10. Solving correctly but omitting all considerations of center of mass -6.**

Need to balance gravitational force against centripetal acceleration and then get period from circumferential velocity. Can use mu and M instead of m1/m2.

4) [25] A 10 meter diameter steel ball is thrown horizontally at 15 m/s in honey (that means you can ignore gravity).
The density of the honey is the same as water. The mass of the ball is 4 million kg. (It's a big ball!). The viscosity of the honey is 100,000 centiPoise.

[4] a) Convert 100,000 cP to proper SI units. What are those units?
100 Pascal-seconds (or N s /m^2 or kg /m s) 2 point for units, 2 points for value.

[8] b) What is the total drag force at t=0 on the ball (include both types of drag)?
4 points per type of drag. Lost substantially for not showing the numbers you are plugging in. F linear = 141000 N, F quad = 4.4 million N. F-total = 4.54 million N.

[4] c) What is the Reynolds number the ball experiences at t=0.
I tried to design this problem with a lower Reynolds number but I picked too large a diameter for the ball. 30 cm would have been better. Anyway, Re = 1500 (dimensionless)

[6] d) Write down (you do not need to derive, but you may) a formula for the horizontal velocity of the ball as a function of time using only linear drag.
v = v_0 exp(-bt/m) = 15 m/s exp(- 3 pi 100 10 / 4E6)
v = v0 - at gave you 2/6
Trying to derive formula but not quite getting there gave you 4 or 5 out of 6.

[3] e) Use the formula you determined in previous part to calculate the speed of the ball at t=2 seconds.
Need exp(-0.0048). Result is 14.92 m/s. Ball did not slow much in 2 seconds.
Usually got full credit for this if you showed your calculation, even if it was wrong.

5) [20] What is the mass of a tennis-ball sized black-hole? An answer is sufficient. Your answer is not quite correct because you used only classical mechanics, but it is close. You are free to estimate the diameter of a tennis-ball.

Answer depends on your estimate for the tennis ball. I said r=3m

M = 2E25 kg. You should have been in this range. -2 or -3 for calculation error (like forgetting to square the speed of light ...)