

1st Midterm - November 16, 2008

Name and Surname:

Student ID:

Department:

Signature:

You should show your work. You will lose points if you do not put the right units and put the vector signs for vectors.

Discussion:

1. What are the Newton's three laws of dynamics? Discuss in detail using words only. (You will lose 2 points for each mathematical relation that you write.) (20 points)

Short Questions:

2. What are the units of velocity? energy? work? in SI units. (10 points)
3. If the position of an object as a function of time t is given by:

$$\vec{r} = (1.2m)\hat{x} + (0.9m/s^2)t^2\hat{y} + (3.5m/s^4)t^4\hat{z} \quad (1)$$

what is the velocity of the object as a function of time? what is the acceleration? (10 points)

Explicit Calculation:

4. Imagine an isolated planet in space. Assume that the shape of the planet is sphere with radius R . If you consider any two parts of the planet, due to their gravitational attraction, they will have a potential energy. The sum of all these potential energies is called the self potential energy of the planet. What is the self gravitational potential energy of the planet if the total mass of the planet is M . (20 points)
5. The unlucky lover (of the homework), eventually gets the attention of his girlfriend. (Then you might ask why he is unlucky) But he also gets the attention of the father of his girlfriend, who starts chasing the boy. Trying to get advantage of his youth, he starts climbing the hill nearby at a constant speed of v_b . The angle that the hill makes with the ground has a constant value of α . When the angry father reaches the start of the hill, the boy is already a distance d away. Since the hill is too steep for the man, he considers throwing a stone to the boy. If the maximum speed

with which he can throw the stone is v_0 , what is the range(measured along the hill) of the stone that he can throw as a function of the angle with which he throws the stone and the slope of the hill. What is the maximum range? What is the maximum distance d such that if d is less than that, the father has a chance to hit the boy? (20 points)

6. Our unfortunate lover is still trying to run away from the father of the girlfriend. Little by little he is getting desperate that he cannot get away from him. He arrives at a river which is 40 m wide, and there is a boat resting on the side of the river. In still water he can row with a speed of 30 m/s . The river is running at a speed of 20 m/s . He has to cross the river and reach the point directly across him. What should be the angle between his rowing direction and coast of the river so that he can reach the other point? How long does it take him to reach the other end? (10 points)
7. When our unfortunate lover reaches the other side, he realizes that the father had taken the other boat to cross the river. As he is trying to find another way to escape, he notices a space cannon which can launch a space capsule with a velocity v . If after being launched, there is no propulsion, what should be the minimum speed v such that the capsule can reach moon? (Let the mass of the moon and the earth be m and M respectively, and the distance between the two R . Let m_c be the mass of the capsule. Denote the radius of the earth and the moon by R_E and R_m respectively. Ignore friction effects.)(Unfortunately, the velocity of the capsule is too slow.To be continued...) (*Hint*: Is it possible to find an initial speed of the cannon such that the cannon can reach the surface of the moon with zero velocity? NO! Why not?) (20 points)

Usefull formulae:

You can use the following formula's without deriving them. For anything else, you need to derive it:

$$\begin{aligned}\vec{F} &= m\vec{a}, \quad \vec{a} = \frac{d\vec{v}}{dt}, \quad \vec{v} = \frac{d\vec{x}}{dt} \\ a_r &= \frac{v^2}{r}\end{aligned}\tag{2}$$

where a_r is the radial acceleration of an object making circular motion on a circle of radius r