MID TERM EXAMINATION

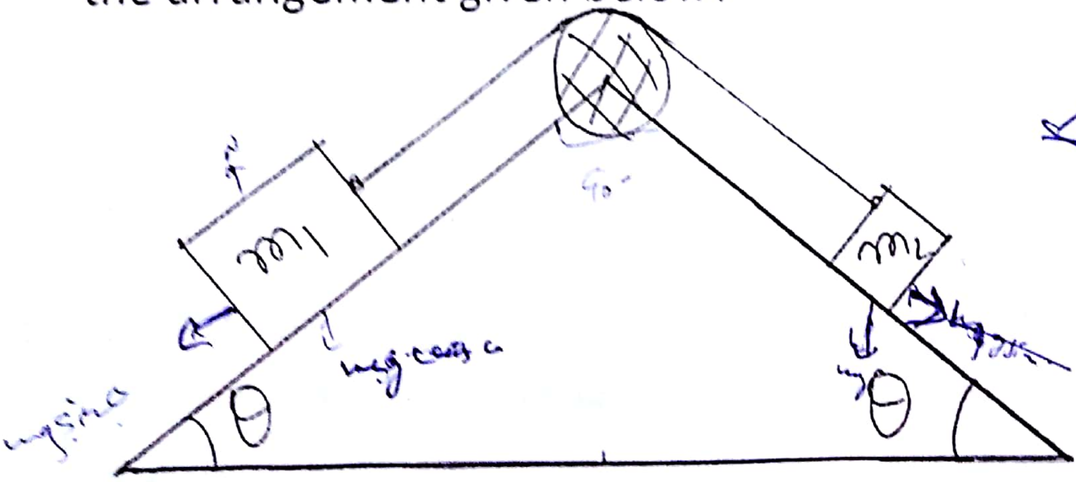
PH1101: August 2015

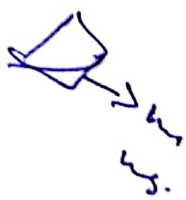
Duration: 1 Hour. Total Marks : 20

Answer ALL Questions 1-5 : 2 points each

1. Acceleration is defined as $d\vec{v}/dt$. However centripetal acceleration is expressed as v^2/R. Explain how the two expressions are consistent?

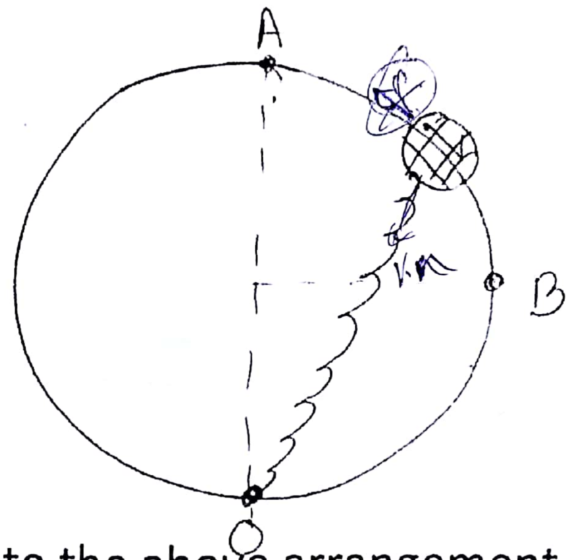
2. How will you determine the direction of friction in the arrangement given below?





3. Draw a velocity vs time graph for the following 1-*d* motion: particle starts from rest with a constant acceleration until it reaches a speed v at time t_1 and continues with that speed till time t_2 and then undergoes a constant deceleration and comes to rest. Show that the distance travelled by the particle is equal to the area under the curve you have drawn.

4.



With reference to the above arrangement, let the velocity of the bead be v_1 at A and v_2 at B.

a)What is the work done by the Normal force exerted by the track on the bead as it moves from A to B . Why?

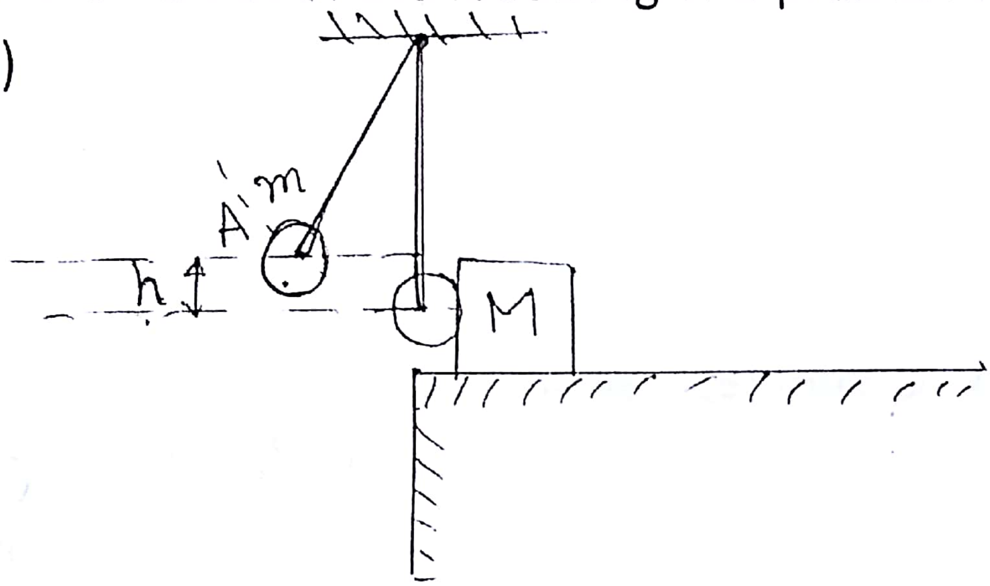
b) What is the work done by the frictional force between track and the bead as it moved from A to B. Assume the unstretched length of the spring to be zero and spring constant to be k.

5. Determine whether the following forces are conservative in nature:

a) $\vec{F} = \alpha(y\hat{\imath} + x\hat{\jmath})$

b) $\vec{F} = ay\hat{\imath}$

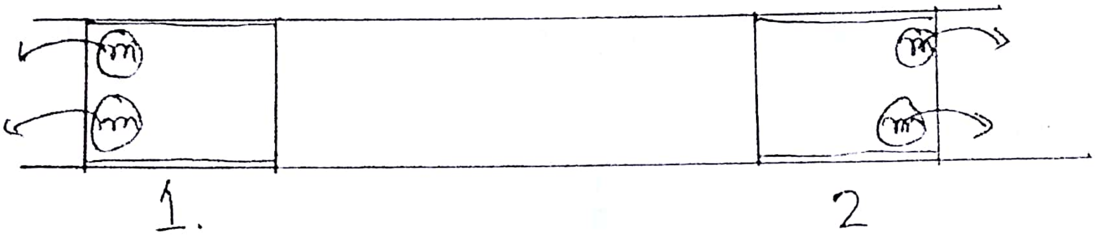
Solve ANY ONE out of the following two problems (10 POINTS)



6. An ideal pendulum of mass m is released from rest from point A that eventually collides with a bar of mass M, resting on a smooth horizontal table.

a)Assuming a perfectly elastic collision, , how high mass m will rise and what will be the velocity of M after the collision?

b) Assuming a perfectly inelastic collision, how high the combined mass will rise after the collision
Draw a neat diagram in both cases.



7. On a frictionless railway track two buggies of mass M each are at rest separated by a large distance. Each buggy is carrying two passengers of mass m each. The passengers can jump of the buggy with a velocity u relative to the buggy. From buggy 1 both passenger jump simultaneously to the left and from buggy 2 the passengers jump one after the other to the right. Find the final relative velocity of buggy 1 with respect to buggy 2.

FINAL EXAM PH1101

26th November 2015

Time: 3 Hours **TOTAL: 50 POINTS**

1. (a)What is the definition of average acceleration?
   (b)A tennis ball is dropped on the floor (zero initial velocity) from a height of *4.05 m* and it rebounds to a height of *3.20 m*. If the ball was in contact with the floor for *0.01 s*, what was its average acceleration vector during contact? (Take $g=10m/s^2$)

   (2 Points)

2. A ball rolls off the edge of a horizontal table *1.25 m* high. If it strikes the floor at a point *1.5 m* horizontally away from the edge of the table,
   (a) what was its velocity at the instant it left the table.
   (b) what is the velocity of the ball at the point of impact with the floor (Take g=10m/s^2)

   (2 Points)

3. (a) State the law of conservation of momentum.

(b) A *75 kg* man standing on a surface of negligible friction kicks forward a *100g* stone lying at his feet, so that it acquires a speed of *25 cm/s*. What velocity does the man acquire as a result? **(2 Points)**

4. An electron and a photon each have a wavelength of *1.0nm*. What is the momentum of the (a) electron and (b) photon? What is the energy (in eV) of the (c) electron and (d) photon? **(2 Points)**

[Given Planck's constant, $h=6.63 \times 10^{-34}$ J.s, and charge of electron, $e=1.6 \times 10^{-19}$ C, mass of electron, $m_e=9.1 \times 10^{-31}$ kg)

5. (a)Write down the exact expression of Heisenberg Uncertainty Principle.

(b)Estimate the minimum errors in determining the velocity of an (a) electron, (b) proton and (c) a ball of mass *1mg* if the coordinates of the particles are known with an uncertainty of $0.5\mu m$.

(2 Points)

6. (a) Express the unit vectors of polar coordinates, $\hat{\boldsymbol{r}}$ and $\hat{\theta}$, in terms of the unit vectors of a Cartesian coordinates, $\hat{\boldsymbol{\imath}}$ and $\hat{\boldsymbol{\jmath}}$, and the polar angle θ.

(b)Derive expressions for $d\,\hat{\boldsymbol{r}}\,/dt$ and $d\,\hat{\theta}\,/dt$ in terms of the $\hat{\boldsymbol{\imath}}$ and $\hat{\boldsymbol{\jmath}}$, θ and $d\theta/dt$.

(c) Define uniform circular motion. Write the expression for the position vector $\vec{\boldsymbol{r}}$ in polar coordinates for a particle undergoing such motion.

(d) From above derive the expression for velocity vector using $\vec{\boldsymbol{v}} = d\vec{\boldsymbol{r}}/dt$.

(e) From the expression of velocity above, find the expression for acceleration vector.

(10 Points)

7. A vessel at rest explodes, breaks into three pieces. Two pieces having equal masses, fly off perpendicular to one another with the same speed of *30m/s*. The third piece has three times the mass of each other piece. What is the direction and magnitude of its velocity immediately after the explosion? **(5 Points)**

8. A bullet of mass m is fired horizontally into a wooden block of mass M at rest on a horizontal surface. The coefficient of kinetic friction between block and surface is μ. The bullet comes to rest in the block which moves a distance d. Find an expression for the original speed of the bullet v in terms of the parameters given. **(5 Points)**

9. (a)Write the equation for a harmonic wave travelling in the negative direction along the x-axis and having an amplitude of *0.010 m*, frequency of *550 Hz* and speed *350m/s*.

(b)How far are two points in space 60^o out of phase, for a given instant?

(c) What is the phase difference between displacements at a fixed point at two different times 10^{-3} *s* apart. **(5 Points)**

$\psi = A e$

10. Consider a one dimensional quantum well of width *a* with infinitely large potential barriers, as described below.

V(x)=0 for 0<x<a and V(x)=infinity otherwise.

(a) Write down the relevant boundary conditions for the wavefunctions.

(b) Write down the time-independent Schrodinger equation for the problem

(c) Solve the above for stationary states , wavefunctions and energy levels.

(d) Normalize the wavefunctions found above.

(e) Write down the time **dependent** wavefunctions corresponding to each stationary state.

(10 Points)

11. Consider the wavefunction for the lowest energy level (*n=1*) for the infinite potential well (Question 10 above). Show that the uncertainty in momentum is given by $\Delta p = \pi\hbar/a$.

(5 Points)

[Given $\int_0^a \sin\left(\frac{\pi x}{a}\right)\cos\left(\frac{\pi x}{a}\right) dx=0$; $\int_0^a \sin^2 \frac{\pi x}{a} dx = \frac{a}{2}$]

$+ \frac{A^2}{a^2}$