I-Year I-Semester 2011-12
Comprehensive Examination

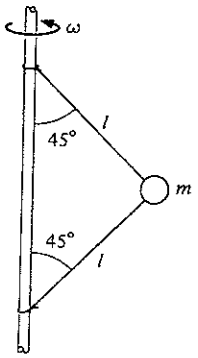
Course Name: Mechanics, Oscillations and Waves | **Course No: PHY F 111**
Date: 09-01-12; | **Weightage: 40%;**
Duration 3hrs | **Max marks : 80**

BITS Pilani
Dubai Campus

ANSWER PART A and PART B IN SEPARATE ANSWER SHEETS

Part A

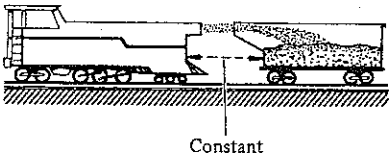
1. A mass m is connected to a vertical revolving axle by two strings of length **l**, each making an angle of **45°** with the axle as shown in figure. Both the axle and mass are revolving with angular velocity **ω**. Gravity is directed downward. a) Draw a clear force diagram for m. b) Find the tension in the upper string, $\mathbf{T_{up}}$ and lower string $\mathbf{T_{low}}$. **(2+4=6)**



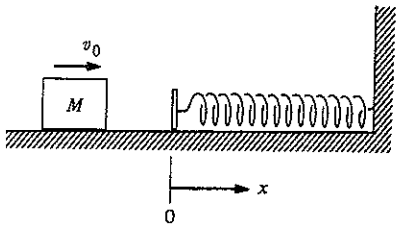
2. Find the shortest possible period of revolution of two identical gravitating solid spheres which are in circular orbit in free space about a midway between them. You can imagine the sphere fabricated from any material obtainable by man. **(4)**

3. Find the center of mass of a thin rectangular plate with sides of length **a** and **b**, whose mass per unit area σ varies in the following fashion ; $\sigma = \sigma_0$ **(xy/ab)**, where σ_0 is a constant. **(6)**

4. A sand spraying locomotive sprays sand horizontally into a freight car as shown in the figure. The locomotive and freight car are not attached. The engineer in the locomotive maintains his speed so that the distance to the freight car is constant. The sand is transferred at a rate **dm/dt = 10kg/s** with a velocity of **5m/s** relative to the locomotive. The car starts from rest with an initial mass of **2000kg**. Find its speed after **100 s**. (Neglect Gravity) **(6)**

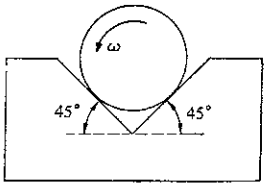


5. A block of mass M slides along a horizontal table with speed $\mathbf{v_0}$. At $\mathbf{x = 0}$ it hits a spring constant **k** and begins to experience a friction force as shown in figure. The coefficient of friction is variable and is given by $\boldsymbol{\mu} = \mathbf{bx}$, where **b** is a constant. Find the loss in mechanical energy when the block has first come momentarily to rest. **(6)**



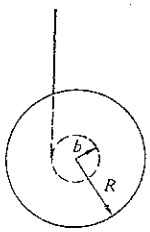
6. A proton makes a head on collision with an unknown particle at rest. The proton rebounds straight back with **4/9** of its initial kinetic energy. Find the ratio of the mass of the unknown particle to the mass of the proton, assuming that the collision is elastic. **(6)**

7. A cylinder of mass **M** and radius **R** is rotated in a uniform **V** groove with constant angular velocity $\boldsymbol{\omega}$. The coefficient of friction between the cylinder and each surface is $\boldsymbol{\mu}$. What torque must be applied to the cylinder to keep it rotating if $\boldsymbol{\mu}$ = **0.5, R = 0.1m , W = 100N**. ($g = 9.8 m/s^2$) **(6)**



Part B

1. A Yo- Yo of mass M has an axle of radius **b** and a spool of radius **R**. Its moment of inertia can be taken to be $\mathbf{MR^2/2}$ and the thickness of the string be neglected. The Yo-Yo is released from rest.
What is the tension in the cord as the Yo-Yo descends and as it ascends? **(3+3=6)**



2. In a damped harmonic oscillator where the friction force is of the form f = -bv, write the equation of motion and using the general solution

$$x = Ae^{-(\gamma/2)t}\cos(\omega_1 t + \phi).$$

Calculate the kinetic energy, potential energy and the total energy of a lightly damped system.**(2+2+2=6)**

3. A musician's tuning fork rings at **440Hz**. A sound level meter indicates that the energy decreases by a factor of 5 in 4s. What is the Q of the tuning fork? **(4)**

4. The equation of a transverse wave traveling along a string is given by **$y = 0.3 \sin \pi (0.5x - 50t)$**, where y and x are in centimeters and t in seconds. a) Find the amplitude, wavelength, wave number, frequency, period and velocity of the wave. b) Find the maximum transverse speed of the any particle in the string **(3+3=6)**

5. Calculate the total kinetic energy in the segment of a string between x = 0 and $x = \lambda$ associated with one complete wavelength of a sinusoidal wave. (Given mass of the small segment is **μdx** and its transverse velocity u_y is **$\delta y/\delta t$ (6)**

6. In a double slit arrangement from a mercury vapor lamp, the strong line λ = 546nm is visible. The slits are 0.12mm apart and the screen on which the interference pattern appears is 55cm,
   a) What is the angular position of the first minimum and 10^{th} maximum **(3)**
   b) What is the distance on the screen between the adjacent maxima. **(3)**

7. A grating has 620 rulings/mm and is 5.50mm wide.
   a) What is the smallest wavelength interval that can be resolved in the third order at λ = 481nm? **(3)**
   b) How many higher orders can be seen? **(3)**

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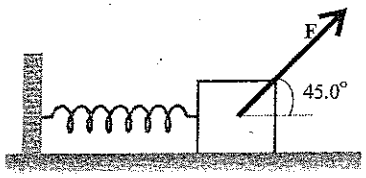
I-Year I-Semester 2011-12
Test II (Open Book)

Course Name: Mechanics, Oscillations and Waves
Course No: PHY F 111 ;

Date: 11-12-11;
Weightage: 20%;

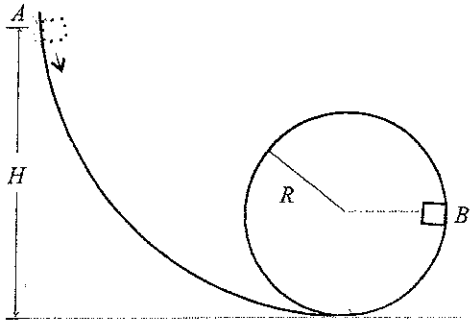
Duration.: 50 minutes;
Max Marks: 40

1. A 5.00 kg block initially rests on a horizontal frictionless floor at the end of an undeformed spring of force constant 100N/m. A force, F, of magnitude 60.0N acts on the block to move it 18.0cm along the floor. Calculate the a) workdone by F, b) workdone by the spring, c) final speed of the block. **(2+2+4=8)**

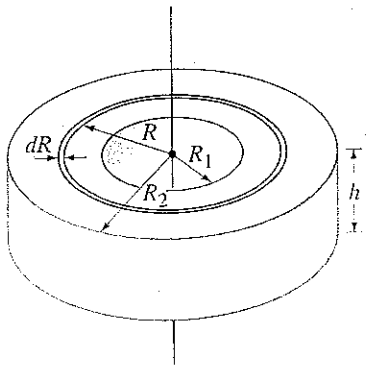


2. Starting from rest a crane fly can attain a speed of 3.1m/s over a distance of 4.5cm. The mass of the fly is about 2.0g. Estimate the average power output of its leg. **(8)**

3. For the loop-the –loop track shown in figure, H= 1.80m and R= 0.540m. A 1.67 kg block is released from rest at point A acquires a speed of 3.25m/s at point B. Find the workdone by the track on the block during the latter's motion. **(8)**



4. Obtain the moment of inertia of a uniform hollow cylinder of inner radius R_1, Outer radius R_2, and mass M. **(8)**



5. The position vector of a 5.0kg particle is given by $\mathbf{r} = [(1.0t^2\text{-}3.0t)\mathbf{i} + 2.0t^3\ \mathbf{j}]$m, where t is the time in seconds. Find the a) torque acting on the particle about the origin, b) angular momentum of the particle about the origin, c) use your results to verify the relation $\boldsymbol{\tau} = \mathbf{dl/dt}$. **(3+3+2= 8)**

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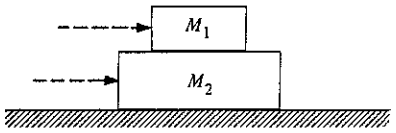
I-Year I-Semester 2011-12
Test I (Closed Book)

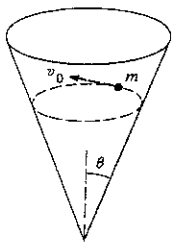
Course Name: Mechanics, Oscillations and Waves **Course No:** PHY F 111 ;
Date: 16-10-11; **Weightage:** 25%;
Duration.: 50 minutes; **Max Marks:** 50

Each question carries 10 marks

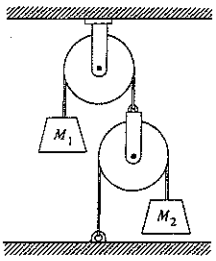
1. A block of mass $\mathbf{M_1}$ rests on a block of mass $\mathbf{M_2}$ which lies on a frictionless table. The coefficient of friction between the blocks is $\boldsymbol{\mu}$. What is the maximum horizontal force which can be applied to block 1 for them to accelerate without slipping on one another.



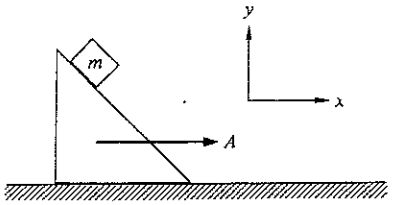
2. A particle of mass **m** slides without friction on the inside of a cone. The axis of the cone is vertical, and gravity is directed downward. The apex half- angle of the cone is $\boldsymbol{\theta}$, as shown in figure. The path of the particle happens to be a circle in a horizontal plane. The speed of the particle is $\mathbf{v_0}$. Draw a force diagram and find the radius of the circular path in terms of $\mathbf{v_0}$, **g** and $\boldsymbol{\theta}$.



3. Masses $\mathbf{M_1}$ and $\mathbf{M_2}$ are connected to a system of strings and pulleys as shown in figure. The strings are **massless** and **inextensible** and the pulleys are **massless** and **frictionless**. Fine the acceleration of $\mathbf{M_1}$. (Assume $M_2 > M_1$)

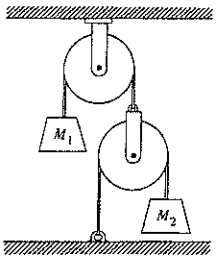


4. A 45^o wedge is pushed along a table with constant acceleration **A**. A block of mass **m** slides without friction on the wedge. Find its acceleration (Gravity is directed down).

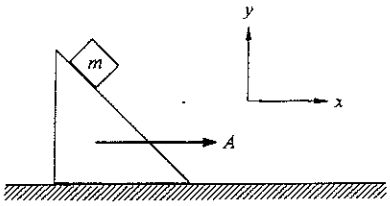


5. The density (mass per unit length) of a thin rod of length **l** varies with the distance x from one end as $\lambda = \lambda_0 x^2/l^2$. Find the position of the center of mass.

3. Masses $\mathbf{M_1}$ and $\mathbf{M_2}$ are connected to a system of strings and pulleys as shown in figure. The strings are **massless** and **inextensible** and the pulleys are **massless** and **frictionless**. Fine the acceleration of $\mathbf{M_1}$. (Assume $M_2 > M_1$)



4. A 45° wedge is pushed along a table with constant acceleration **A**. A block of mass **m** slides without friction on the wedge. Find its acceleration (Gravity is directed down).



5. The density (mass per unit length) of a thin rod of length **l** varies with the distance x from one end as $\lambda = \lambda_0 x^2/l^2$. Find the position of the center of mass.

Name:
Id NO:
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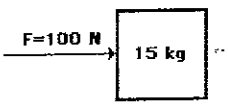
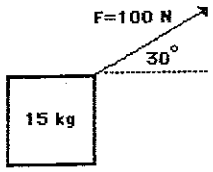
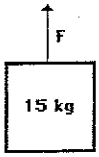
A

I-Year I-Semester 2011-12
Quiz II

Course Name: Mechanics, Oscillations and Waves
Course No: PHY F 111 ;
Date: 28-11-11;
Weightage: 7%;
Duration.: 20 minutes;
Max Marks: 14

1. How large a force is

2. Apply the work equation to determine the amount of work done by the applied force in each of the three situations described below. ($g = 9.8 m/s^2$) (3)

Diagram A	Diagram B	Diagram C
		
A 100 N force is applied to move a 15 kg object a horizontal distance of 5 meters at constant speed.	A 100 N force is applied at an angle of 30° to the horizontal to move a 15 kg object at a constant speed for a horizontal distance of 5 m.	An upward force is applied to lift a 15 kg object to a height of 5 meters at constant speed.

3. A 10kg weight slide from rest down a rough inclined plane, 100cm long and inclined 30^{o} to the horizontal, and gains a speed of 50m/s as it reaches bottom. Find the work done against friction. ($g = 10m/s^2$) (3)

4. The potential energy of a certain particle is given by $U = 20x^2 + 35Z^3$. Find the vector force exerted on it. (2)

5. A 1 kg object, A, with a velocity of 4.0m/s to the right, strikes a second object, B, of 3kg, originally at rest. In the collision, A is deflected from its original direction through an angle of 50^{o}; its speed after the collision is 2m/s. find the angle between B's velocity after the collision and the original direction of A, and find the speed of B after collision. **(3)**

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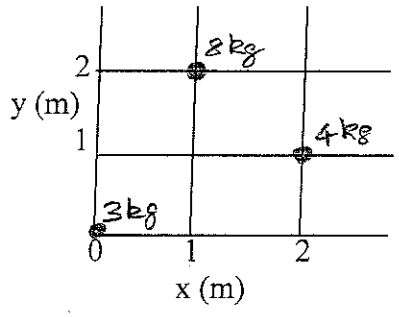
A

I-Year I-Semester 2011-12
Quiz I

Course Name: Mechanics, Oscillations and Waves
Course No: PHY F 111 ;
Date: 31-10-11;
Weightage: 8%;
Duration.: 20 minutes;
Max Marks: 16

1. Where is the Center of Mass of the three particles shown in figure: (3)



2. Derive an expression for Center of mass of a uniform rod of mass M and length L (3)

3. Jennifer who has a mass of 50kg is riding at 35m/s in her red sports car. When she must suddenly slam on the brakes to avoid hitting a deer crossing the road she strikes the air bag that brings her body to a stop in 0.500s. What average force does the seat belt exert on her. (3)

4. If a 5kg object experiences 10N force for a duration of 0.10sec, then what is the momentum change of the object. (3)

5. A rocket , set for vertical launching has a mass of 50kg and contains 450kg of fuel. It can have a maximum exhaust speed of 2km/s. . If $g = 10m/s^2$ what should be the minimum rate of fuel consumption to just lift it off the launching pad. (3)

6. A rocket works on the principle of conservation of
   a) mass, b) kinetic energy, c) linear momentum, d) angular momentum (1)