BITS Pilani, Dubai Campus
Dubai International Academic City, Dubai

1st Year, FIRST SEMESTER : 2012 – 2013

COMPREHENSIVE EXAMINATION (CLOSED BOOK)

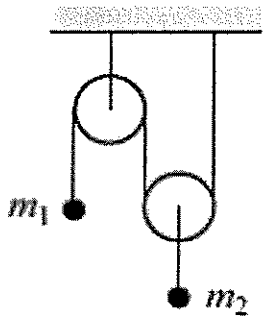
Course Code:	**PHY F111**	Date:	**31.12.2012**
Course Title:	**Mechanics, Oscillations and Waves**	Maximum Marks:	**80**
Duration:	**3 hours**	Weightage:	**40%**

Instructions : ***Answer ALL the questions. Use g = 9.8 ms^{-2} where ever necessary. g acts vertically downwards. Draw a rough sketch at all the suitable places. The paper consists of 12 questions in PART-A, PART-B and PART-C. Answer PART-A, PART-B and PART-C in separate answer books.***

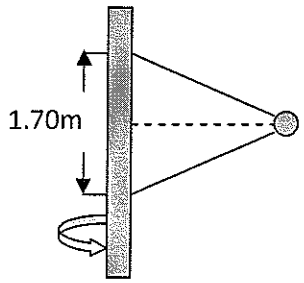
PART - A

Q1. A particle moves in a plane with constant radial velocity $\dot{r} = 4$ ms^{-1}. The angular velocity is constant and has magnitude $\dot{\theta} = 2$ rads^{-1}. When the particle is **3** m from origin, find the magnitude of (a) velocity and (b) acceleration. **[5M]**

Q2. Consider the pulley system shown below with masses m_1 and m_2. The strings and pulleys are massless. What are the accelerations of the masses? What is the tension in the string? Find the relation between the masses for the whole arrangement to be at rest? Assume $m_2 > m_1$. **[6M]**

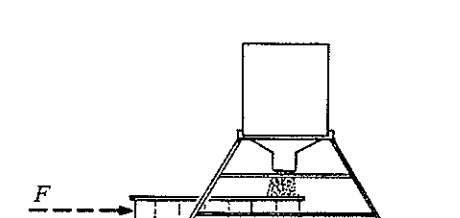


Q3. A **1.34** kg ball is attached to a rigid vertical rod by means of two massless strings each **1.70** m long. The strings are attached to the rod at points **1.70** m apart. The system is rotating about the axis of the rod, both strings being taut and forming an equilateral triangle with the rod as shown in the diagram. The tension in the upper string is **35** N. (a) What is the tension in the lower string? (b) What is the net force on the ball at the instant shown in the figure? (c) What is the speed of the ball? **[6M]**



Q4. **(a)** Consider a two dimensional uniform right angular sheet of mass **M**, base **b**, height **h** and small thickness **t**. Find the center of mass of this sheet in terms of **b** and **h**. **[6M]**

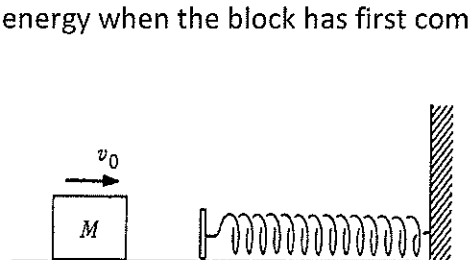
(b) An empty freight car of mass **500** kg starts from the rest under an applied force of **F = 100** N. At the same time sand begins to run into the carat steady rate of **20** kgs^{-1} from a hopper at rest along the track. After **10** s, find the speed of the freight car. **[5M]**



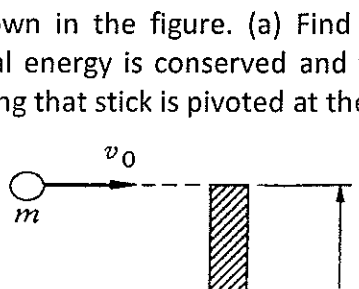
PART - B

Q5. A particle of mass **m** and velocity v_0 collides elastically with a particle of mass **M** initially at rest and is scattered through angle **ɵ** in the center of mass system. Find the final velocity of **m** in the laboratory system. **[7M]**

Q6. A block of mass **M** slides along a horizontal table with speed v_0. At **x = 0** it hits a spring with spring constant **k** and begins to experience a friction force (see the figure below). The coefficient of friction is variable and is given by $\mu = bx$, where **b** is a constant. Find the loss in mechanical energy when the block has first come momentarily to rest. **[7M]**



Q7. A plank of length **2L** and mass **M** lies on a frictionless plane. A ball of mass **m** and speed v_0 strikes its end as shown in the figure. (a) Find the final velocity of the ball, v_f , assuming that mechanical energy is conserved and that v_f is along the original line of motion.(b) Find v_f assuming that stick is pivoted at the lower end. **[7M]**



Q8. Find the moment of inertia of thin sheet of mass M in the shape of an equilateral triangle about an axis through a vertex, perpendicular to the sheet. The length of each side is L. **[6M]**

PART - C

Q.9 A particle oscillates with simple harmonic motion along the x axis. Its position varies with time according to the equation $\mathbf{x = (4.00m)\cos(\pi t + \frac{\pi}{4})}$ where t is in seconds,

a) Determine the amplitude, frequency and period of the motion.
b) Calculate the velocity and acceleration of the particle at any time **t**.
c) What are the position and the velocity of the particle at **t=0**.
d) Determine the maximum velocity and maximum acceleration of the particle

[3+3+2+2= 10M]

Q10. A block has a mass of **1.52** kg and k = **8.23** N/m. frictional force is given by $-\mathbf{b}\left(\frac{dx}{dt}\right)$ where **b** = **227**g/s. Suppose that the block is pulled aside a distance **12.5** cm and released, calculate time interval required for the amplitude to fall $\left(\frac{1}{3}\right)^{rd}$ of its initial value. How many oscillations are made by the block in this time. **[3+3= 6M]**

Q11. The phase velocity **V** of transvers waves in a crystal of atomic separation a is given by $\mathbf{V} = \frac{sinka/2}{k\,a/2}$ where **k** is wave number and **c** is a constant. Show that the value of the group velocity is $\mathbf{c}\cos\frac{ka}{2}$. **[4M]**

Q12. (a) Find the slit separation of a double slit arrangement that will produce bright interference fringes **1.00°** apart in angular separation. Assume wavelength **592** nm.

(b) Sodium light **(λ =589nm)** falls on a double slit of separation **0.180mm**. A thin lens of focal length of **1.13m** is placed near the slit. What is the linear fringe separation on a screen placed in the focal plane of the lens? **[2.5+2.5=5M]**

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ALL THE BEST

Wish you a very happy new year – 2013

BITS Pilani, Dubai Campus
Dubai International Academic City, Dubai

1st Year, FIRST SEMESTER : 2012 – 2013

TEST- 2 (Open Book)

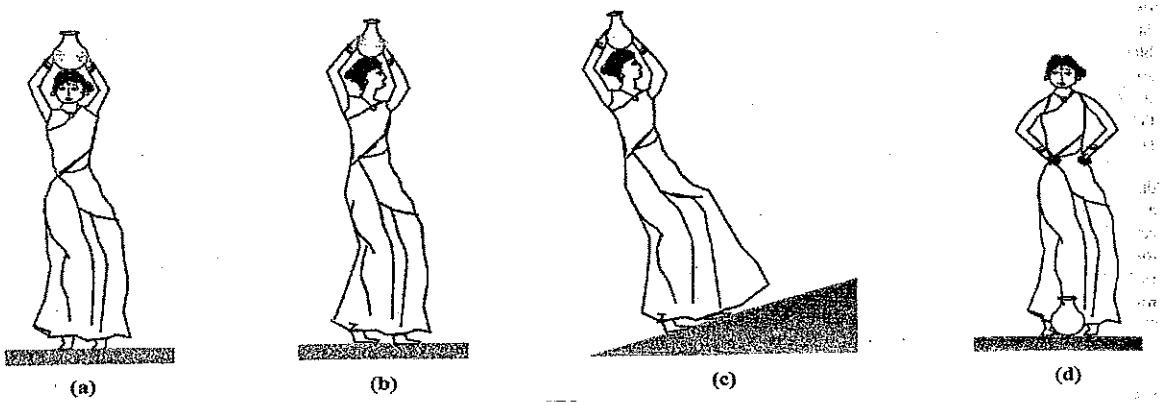
Course Code:	**PHY F111**	Date:	**18.11.2012**
Course Title:	**Mechanics, Oscillations and Waves**	Maximum Marks:	**40**
Duration:	**50 minutes**	Weightage:	**20%**

Instructions : ***Answer all the questions. Use g = 9.8 ms^{-2} where ever necessary. g acts vertically downwards. Draw the rough sketch at all the suitable places.***

Q1. A projectile of mass 9.6 kg is launched from the ground with initial velocity of 12.4 ms^{-1} at an angle of 54^0 above the horizontal. At some time after its launch, an explosion splits the projectile into two pieces. One piece of mass 6.5 kg is observed at 1.42 s after the launch at a height of 5.9 m and a horizontal distance of 13.6 m from the launch point. Find the location of the second fragment at that same time. Neglect air resistance. **[6 M]**

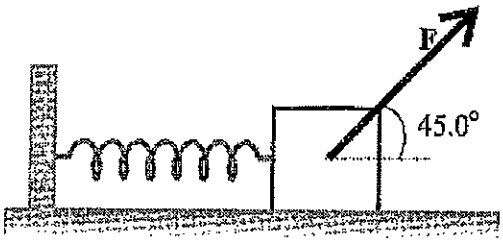
Q2. A rocket of mass 8000 kg is set for vertical firing. (a)For the speed of exhaust is 980 ms^{-1}, find the gas that may be ejected per second in order to supply the thrust which is needed to overcome the weight of the rocket. (b) If the rocket is to have an initial upward acceleration of 19.6 ms^{-2}, find the rate at which the gas has to be ejected. Assume that the speed of the exhaust is 980 ms^{-1} in this case also. **[6 M]**

Q3. A 1.65m tall milk-maid lifts a 10kg pitcher very slowly from the ground onto to her head (Fig: a), walks 12m along a level road (Fig: b), climbs 4m up a ramp (inclined at an angle 15°) at constant speed (Fig :c), and finally lowers the pitcher very slowly on the floor (Fig : d). Calculate the work done by the milkmaid, the work done by gravity and the net work done on the pitcher during each of these four actions. Neglect the weight of the milk-maid. **[8M]**



(a) (b) (c) (d)

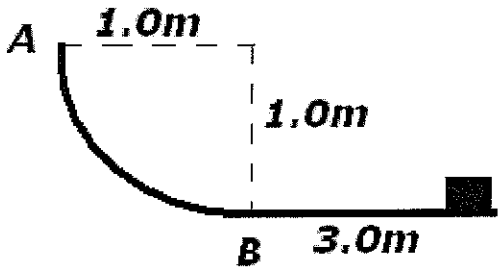
Q4(a). A 5kg block initially rests on a horizontal frictionless floor at the end of an undeformed spring of force constant 100N/M (Fig : 1).A force F. of magnitude 60N acts on the block to move it 18cm along the floor. Calculate the (i) work done by F, (ii) work done by the spring , (iii) final speed of the block. **[6M]**



Q5(a). Consider an elastic collision of two particles of mass m_1 and m_2 in the center of mass frame. Show that the speed of each particle is the same before and after the collision.

(b). A particle of mass m_1, moving with a velocity u_1, collides head on with a particle of mass m_2 at rest, such that , after collision, they travel with velocities v_1 and v_2 respectively. If the collision be an elastic one, show that $v_2 = \frac{2u_1}{\left(1+\frac{m_2}{m_1}\right)}$. **[4 M + 4 M]**

Q6. A block is released at A and slides without friction until reaches at point B. The horizontal part is not smooth. If the block comes to rest 3.0 m from B, what is the coefficient of friction. **[6 M]**



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ALL THE BEST

BITS, PILANI – DUBAI

1st Year, FIRST SEMESTER:2012 – 2013

TEST- 1 (Closed Book)

Course Code:	**PHY F111**	Date:	**30.09.2012**
Course Title:	**Mechanics, Oscillations and Waves**	Maximum Marks:	**50**
Duration:	**50 minutes**	Weightage:	**25%**

Instructions : ***Answer all the questions. Use g = 9.8 ms^{-2} where ever necessary. g acts vertically downwards. Draw the free body diagrams at all the suitable places.***

Q1. If the difference of two unit vectors is a unit vector then find the magnitude of their resultant. **[6 M]**

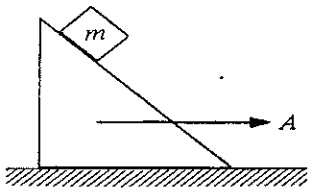
Q2. A particle moves outward along a spiral. Its trajectory is given by $r = A\theta$, where A is a constant and is equal to $\frac{1}{\pi}$ m rad^{-1}. θ increases in time according to $\theta = \frac{1}{2}\alpha t^2$, where α is a constant.

(a) Find the radial acceleration when $\theta = \frac{1}{\sqrt{2}}$.

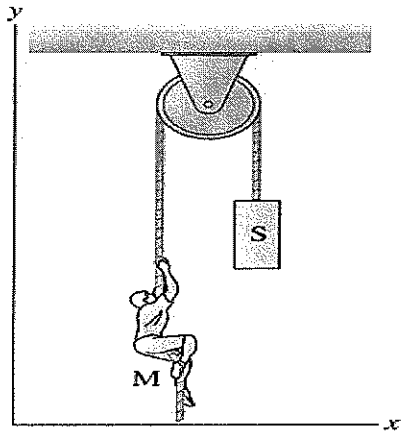
(b) Find the angle at which the radial and tangential accelerations are having same magnitude. **[8 M]**

Q3. An elevator is going upward with an acceleration 4ms^{-2}, calculate the tension in the string of a simple pendulum attached in the elevator, if its bob is of mass 0.2 kg. **[4 M]**

Q4. A 30^0 wedge is pushed along a table with constant acceleration A. A block of mass m slides without friction on the wedge. Find the acceleration of the block. **[10 M]**



Q5. A 200kg set (S) used in a play is stored in the loft above the stage. The rope holding the set passes up and over a pulley, then it tied backstage. The director tells a 100 kg stagehand to lower the set. When he unties the rope, the set falls and the unfortunate man is hoisted into the lost. What is the stage hand's acceleration? **[6 M]**



Q6. A block of mass M rests on a smooth and frictionless horizontal surface. A body of mass m is kept on the block as shown. The coefficient of friction between the body and the block is μ. For what value of F applied on the block will the body begin to slide over the block? In what time will the body from the block if the length of the block is L. **[8 M]**

Q7. Three particles of mass 'm' each rotate in a circle of radius 'r' with uniform angular speed under their mutual gravitational attraction. If at any instant the points are on the vertex of an equilateral triangle of side 'L', then find angular velocity in terms of constant of gravitation (G), length(L) of the triangle and the mass (m). **[8 M]**

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BITS Pilani, Dubai Campus

1st Year, FIRST SEMESTER:2012 – 2013

Set - A

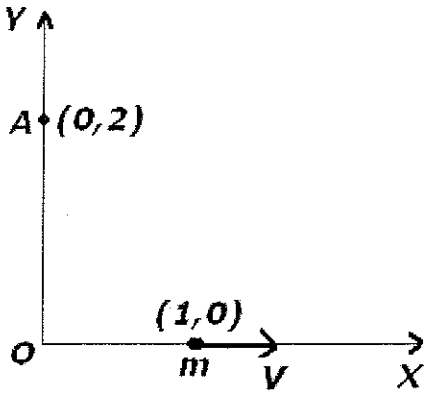
QUIZ - 2

Course Code:	**PHY F111**	Date:	**04.12.2012**
Course Title:	**Mechanics, Oscillations and Waves**	Maximum Marks:	**14**
Duration:	**20 minutes**	Weightage:	**7%**

Name of the student		**ID No.**	
Name of the faculty		**Section:**	

Instructions : ***Answer all the questions. Use g = 9.8 ms^{-2} where ever necessary.***

Q1. A particle of mass(m) 25 g is moving in X-direction with a velocity(V) 16 ms^{-1} at a given instant of time as shown in the diagram. Find the angular momentum of the particle about the point A at that instant of time. **[2 M]**



Q2. In the above problem, if the mass slows down due to friction of 0.8 N, find the **Torque** acting on the particle about A. **[2M]**

Q3. A light rope wrapped around a disc shaped pulley is pulled tangentially with a force of 3 N. Find the angular acceleration of the pulley, given that its mass is 1 kg and its radius is 0.1 m. **[2M]**

Q4. Deduce the expression for the rotational inertia of a thin rod of mass 'M' and length 'L' about an axis passing through its center of mass and perpendicular to its length and hence determine its rotational inertia about an axis perpendicular to its length and passing through one of its ends. **[4M]**

Q5. The moment of inertia of a thin disc about its central axis is I. Another disc is made of the same material and thickness but of double its radius. Find the moment of inertia of this disc in terms of I. [2**M**]

Q6. Write the expression for the moment of inertia of a solid sphere about a diametrical axis and about a tangent. Assume its mass and radius as M and R respectively. **[2M]**

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Set - A

BITS Pilani, Dubai Campus

1st Year, FIRST SEMESTER:2012 – 2013

QUIZ - 1

Course Code:	**PHY F111**	Date:	**23.10.2012**
Course Title:	**Mechanics, Oscillations and Waves**	Maximum Marks:	**16**
Duration:	**20 minutes**	Weightage:	**8%**

Name of the student		**ID No.**
Name of the faculty		**Section:**

Instructions : ***Answer all the questions. All questions carry equal marks. Use g = 9.8 ms^{-2} where ever necessary.***

Q1. A spaceship with a total mass of **13600 kg** is moving relative to a certain inertial reference frame with a speed of **960 ms^{-1}** in a region of space of negligible gravity. It fires its rocket engines to give an acceleration parallel to the initial velocity. The rockets eject gas at a constant rate of **146 kgs^{-1}** with a constant speed relative to the spaceship of **1520 ms^{-1}** and they are fired until **9100 kg** of fuel has been burned and ejected. What is the **thrust produced** by the rockets?

Q2. In the above problem, find the **velocity of the spaceship** after the rockets have been fired?

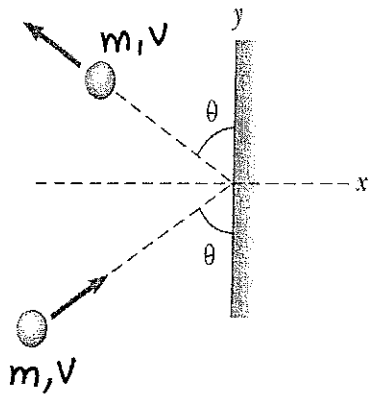
Q3. Water shoots out from a fire hydrant having a nozzle diameter **3cm** with a nozzle speed **30ms^{-1}**. Assuming the density of water as **1 gcc^{-1}**, estimate the **reaction force** on the fire hydrant.

Q4. The masses of the sun and the earth are **2.0 x 10^{30} kg** and **6.0 x 10^{24} kg** respectively. The distance between them is **1.5 x 10^{11} m**. The radius of the sun is **7.0 x 10^{8} m**. Use these data to determine whether the center of mass of earth-sun system lies **inside or outside the sun**. Justify your answer.

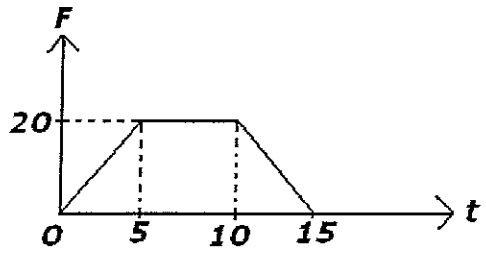
Q5. The density of a thin rod of length '**L**' varies with the distance '**X**' from one end as $\rho = \frac{\rho_0 x^3}{L^3}$. Find the **position** of center of mass.

Q6. A machine gun fires **6 bullets per second** into a target. The mass of each bullet is **3 g**, and the speed **500 ms^{-1}**. Find the **average force** required to hold the gun in position.

Q7. A particle of mass '**m**' moving with a velocity '**V**' collides with a wall and bounce back with same speed as shown in figure. Calculate the **impulse** experienced by the wall.



Q8. A particle of mass **10 g** collides with an object, whose **F vs t** graph is given in the figure. Calculate the **impulse** experienced by the particle.



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