BITS, PILANI – DUBAI
International Academic City, Dubai

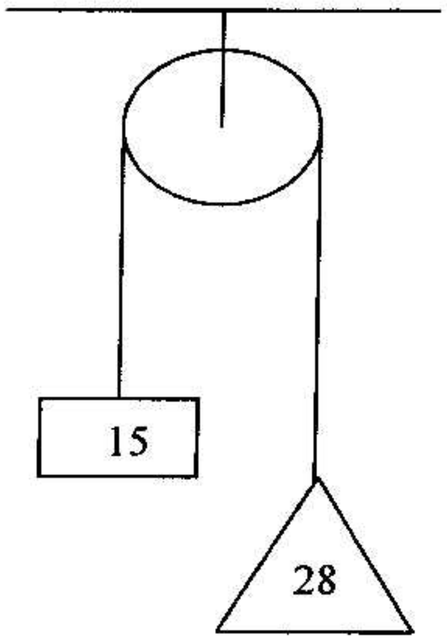
I-Year I-Semester 2009-10
COMPREHENSIVE EXAM (Closed Book)

Course Name:	Physics I;	**Course No.:**	PHY C131;
Date:	22nd Dec'09;	**Weightage:**	40%;
Duration.:	3 Hrs;	**Max Marks:**	120

Note: All Sections are Compulsory

Section A

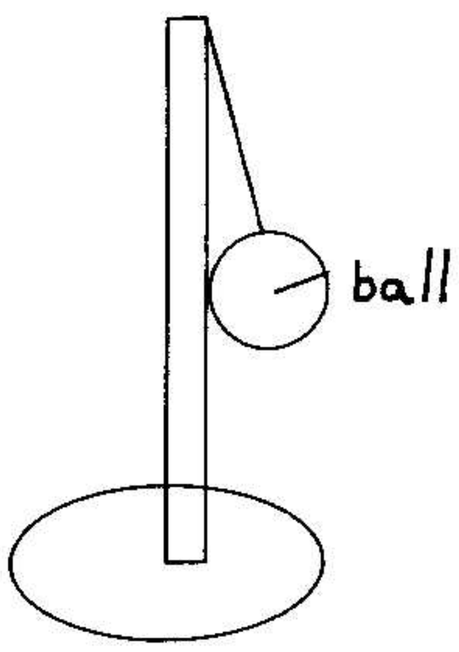
1. A 15 Kg load of bricks hangs from one end of a rope that passes over a small massless pulley. A 28 Kg counterweight is suspended from the other end of the rope. The system is released from rest.
   a) Draw two free body diagrams, one for the load and one for the counter weight.
   b) What is the magnitude of the upward acceleration of the load of bricks?
   c) What is the tension in the rope while the load is moving? (2+3+3=8)



2. A 550 N man stands on a weighing scale in an elevator. As the elevator starts moving, the scale reads 450 N. (given g= 9.80 m/s^2)
   a) Find the acceleration of the elevator (magnitude and direction).
   b) What is the acceleration if the scale reads 800 N.
   c) Explain in which situation the scale reads zero.

   (3+3+2=8)

3. A ball leans against the pole to which it is attached as in figure. If the string to which the ball is attached is 1.4 m long and the ball has a radius of 0.110 m and a mass of 0.27 Kg, what is the tension in the rope and the force the pole exerts on the ball? Neglect any friction between the ball and the pole. The string is attached to the ball such that a line drawn along the string passes through the center of the ball. (5+3=8)



4. Calculate the centre of mass of a uniform right triangular sheet of mass M, base b, height h and small thickness t . (12)

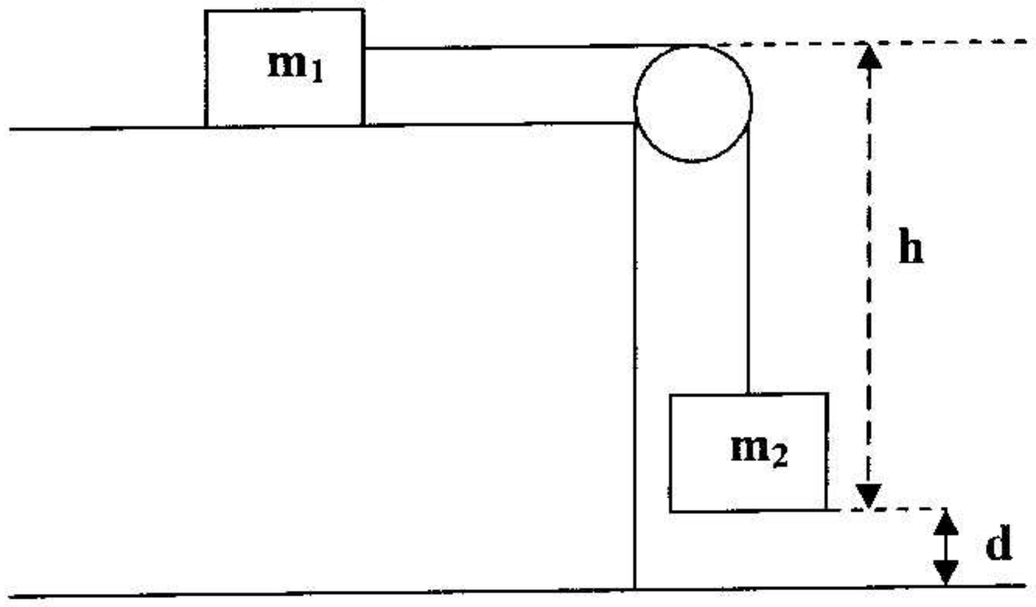
5. A fully fueled rocket has a mass of 21,000kg of which 15,000kg is fuel. The fuel is burned out the rear at a rate of 190kg/s with a speed of 2800m/s relative to the rocket. If the rocket is fired vertically upward, calculate
   a) the thrust of the rocket,
   b) what is the minimum force required to just lift up the rocket
   c) its final velocity when the fuel is completely burnt out. Ignore air resistance and assume the acceleration due to gravity is constant at $g = 9.80 m/s^2$.
   (3+3+6=12)

Section B

6. A wooden block of mass 0.9 kg is suspended from the ceiling of a room by thin wires. A bullet of mass 0.1 kg moving horizontally with a speed of 10 ms^{-1} strikes the block and sticks to it. Find the height to which the block and the bullet system rises. Take the acceleration due to gravity as 10 ms^{-2}. (8)

7. A mass 'm' is shot vertically upward from the surface of the earth of radius R with initial speed 'v'. Assuming that the only force is gravity, find its maximum altitude and the minimum value of velocity for the mass to escape the earth completely using work and energy theorem. (8)

8. A block of mass m_1= 2.4 kg is connected to a second block of mass 1.8 kg as shown in the diagram. When the blocks are released from rest, they move through a distance d = 0.5 m at which m_2 hits the floor. Given the coefficient of friction between m_1 and the horizontal surface is 0.45, find the speed of the blocks just before m_2 lands. (Given $g = 9.8\ m/s^2$) (8)



9. Derive the expression for moment of inertia of a uniform solid sphere of mass M and radius R about an axis passing through the center of the sphere. (12)

10. Consider a harmonic oscillation of a particle of mass M attached with spring of spring constant k . The resistive force acting on the particle is bv where b is a constant and v is the velocity of the particle.
    (a) Write the equation of motion of the particle with solution
    (b) Derive the expression for average KE and average PE for the lightly damped system
    (c) Derive the expression for the quality factor for the lightly damped system
    (4+4+4=12)

Section C

11. The phase velocity 'v ' of a wave of wavelength λ is given below as

$$\frac{1}{v^2} = \frac{1}{c^2}\left[A + \frac{B}{\lambda^2} - D\lambda^2\right],$$

Where, A, B and D are constants and c is the velocity of light in free space.

Show that the group velocity $v_g = C\left[\dfrac{A + \dfrac{2B}{\lambda^2}}{\sqrt{A + \dfrac{B}{\lambda^2} - D\lambda^2}}\right]$. (8)

12. A glass sheet (n_1=1.5) is coated with a uniform coating of a transparent substance of refractive index n_2=2.42 so as to form the 9th bright blue fringe at an angle of at least 32˚away from the normal. (Given **λ = 472.5nm)**
    (a) What is the thickness of the coating?
    (b) What would be the condition for maxima at the same point if we change the coating to the one with n=1.26? (You may draw a diagram)

(6+2=8)

13. In a double slit experiment, the distance between the slits and the screen is 136 cm. If a light of wavelength λ= 632.8 nm falls on this double slit which has a slit width of 0.124 mm and a separation of 0.372 mm

    (a) What is the fringe width of the interference pattern?
    (b) At what distance from the centre (in mm) would you get the second diffraction minima on the screen ?
    (c) Which would be the missing fringe for the position calculated in part (b)?

(3+3+2=8)

BITS, PILANI – DUBAI
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I -Year I -Semester 2009-10
Test II(Open Book)

Course Name:	Physics I;	**Course No:**	PHY C131;
Date:	15-11-09;	**Weightage:**	20%;
Duration.:	50 minutes;	**Max Marks:**	60

Note: ALL QUESTIONS ARE COMPULSORY

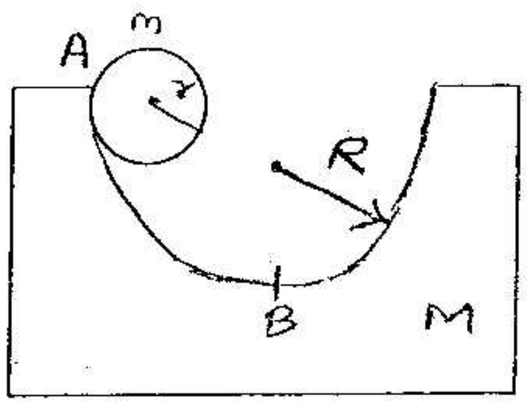
1. The linear momentum **p** of a body of mass 2kg varies with time **t** as $\mathbf{p = 3t^2 + 4}$.
   a) What is the acceleration of the body at $\mathbf{t = 2s}$ **(4)**
   b) What is the force acting on the body in relation with time t. **(4)**

2. Two billiard balls each of mass 50g moving in opposite directions each with a speed $6ms^{-1}$collide and rebound with the same speed. What is the impulse imparted to each ball due to the other. **(4)**

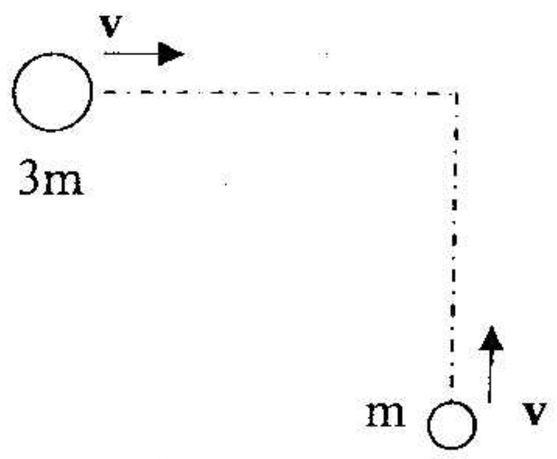
3. a) A rocket is in outer space, far away from any planet, when its engine is turned on. In the first second of firing, the rocket ejects 1/120 of its mass with a relative speed of 2400m/s. What is the rocket's initial acceleration? **(8)**

   b) Suppose that ¾ of the initial mass m_o of the rocket is fuel, so the final mass is $m = m_o/4$, and it is completely consumed at a constant rate in a time of t = 90 s. If the rocket starts from rest, find its speed at the end of this time. **(4)**

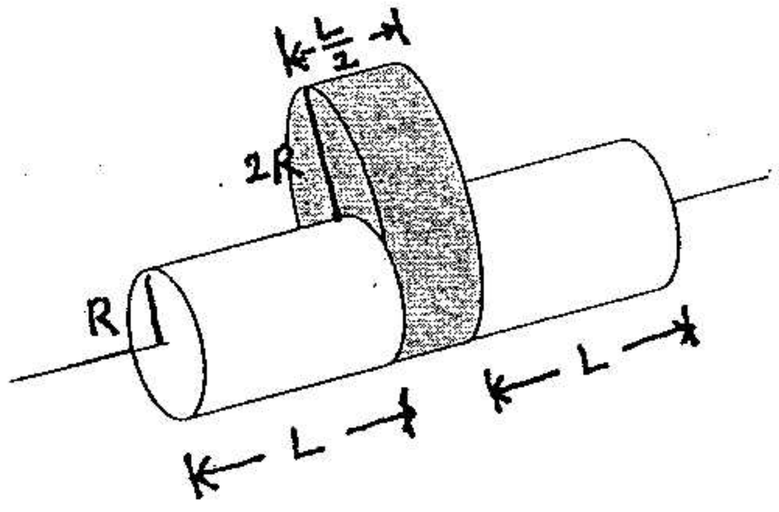
4. A block of mass M having a semicircular track of radius R rests on a horizontal frictionless surface. A uniform cylinder of radius r and mass m is released from rest at point A. The cylinder slips on a semicircular frictionless track. How fast is the block moving when the cylinder reaches the point B. **(12)**



5 Two balls, one of mass m and the other of mass 3m are approaching one another moving at same speed and the angle between their tracks is 90^0. They collide elastically, and the lighter ball is deflected through 90^0, what is the angle of deflection of the other ball. **(12)**



6. Calculate the moment of inertia of the following system about the axis passing through the centre of the solid cylinders shown. The radius of the disk is twice the radius of the cylinders (R). The length of the cylinders is L each and the thickness of the disk is L/2 and the mass of all the three is same, M each. **(12)**



BITS, PILANI – DUBAI
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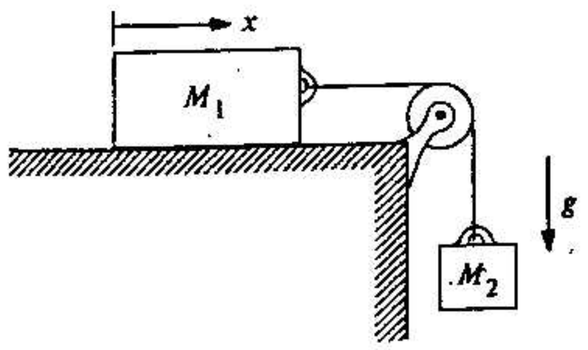
I -Year I -Semester 2009-10
Test I (Closed Book)

Course Name: Physics I; **Course No.:** PHY C131;
Date: 27-09-09; **Weightage:** 25%;
Duration.: 50 minutes; **Max Marks:** 75

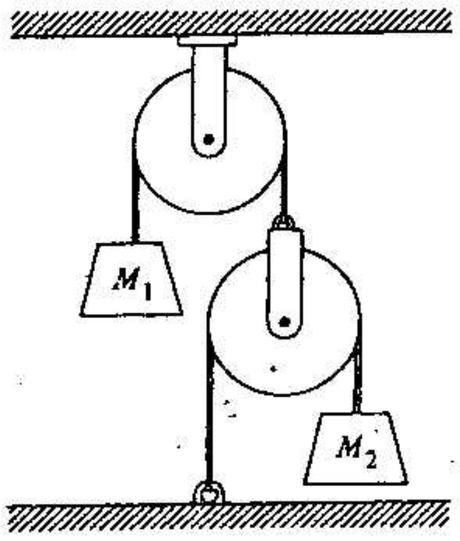
Note: ALL QUESTIONS ARE COMPULSORY AND CARRY 15 MARKS EACH

1. An airplane trip involves three legs (AB, BC, CD), with two stopovers (B and C) as shown in figure. The first leg is due east for 620km, the second leg is southwest 45°for 440km and third leg is at 53° south of west for 550km. What is the plane's total displacement (AD). (15)

2. The two blocks shown in figure are connected by a string of negligible mass. If the system is released from rest, find how far block M_1 slides in time t. Neglect friction. (15)



3. Masses M_1 and 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.Find the acceleration of M_1. (15)



P.T.O

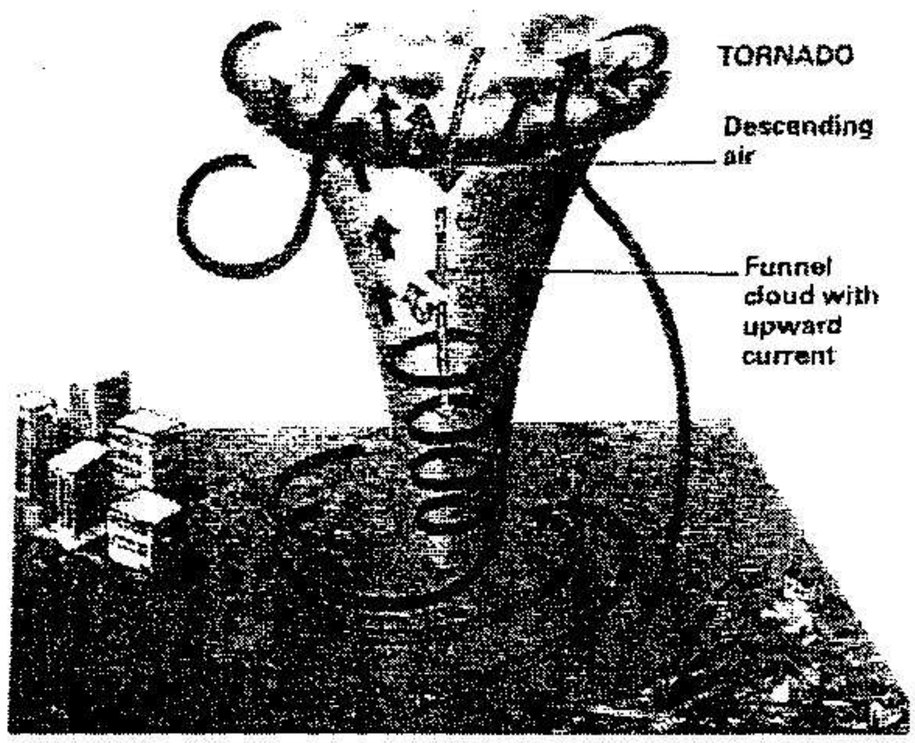
4. A sensor used for studying and recording twisters is thrown into a twister (tornado) and its motion is recorded as follows

$$\theta(t) = 4t^3 + 5t^2 + 3t$$

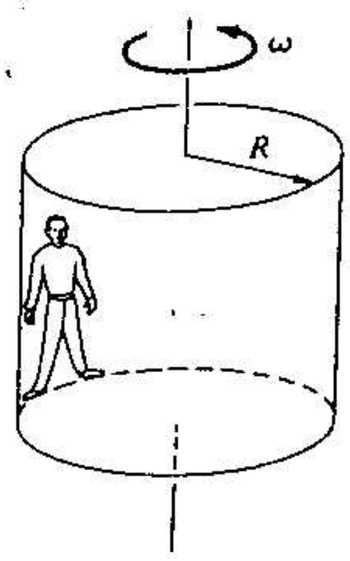
$$r(t) = -3t^3 + 8t^2 + 2t$$

where θ(t) is the angular displacement and r (t) is the radial displacement of the sensor. Using the expression of acceleration in polar coordinates, calculate, at time t=2 secs and t=5 secs.

i) radial acceleration, ii) tangential acceleration, iii) Net acceleration (Magnitude and direction) (Note: the direction should be calculated with respect to the radial direction, ŕ). (15)



5. The spinning terror is an amusement park ride – a large vertical drum of radius R which spins so fast that a person of mass M inside stays pinned against the wall when the floor drops away. What is the minimum steady angular velocity ω which allows the floor to be dropped away safely. Coefficient of friction between the drum and the person is μ and acceleration due to gravity is g. (15)



Name :	ID No:	Sec No:

BITS, PILANI – DUBAI
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I -Year I -Semester 2009-10

Quiz II **VERSION A**

Course Name:	Physics I;	**Course No.:**	PHY C131;
Date:	25-11 -09;	**Weightage:**	7%;
Duration.:	20 minutes;	**Max Marks:**	21

1. An artificial satellite is placed into an elliptical orbit about the earth. Telemetry data indicate that its point closest approach is $R_P = 8.37 \times 10^6$ m from the center of the earth, and its point of the greatest distance is $R_A = 25 \times 10^6$ m from the center of the earth. The tangential speed of the satellite at the closest approach is $V_P = 8450$ m/s. Find the speed, V_A, at the greatest distance. (5)

2. A force of 200N acts at an angle of 40° to a spoke of the wheel of radius 25cm. Find the torque. (4)

3. Compute the rotational kinetic energy of a 25kg wheel rotating at 6rev/s if the radius of gyration of the wheel is 0.22m. (4)

4. Calculate the average of sinωt over a period of cycle. (4).

5. Given the standard solution of the frictionless harmonic oscillator as
   $\mathbf{x = Acos(\omega t + \Phi)}$. Find the total energy of the system (4)

Rough Work

Name :	ID No:	Sec No:

BITS, PILANI – DUBAI
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I -Year I -Semester 2009-10
Quiz I

Course Name:	Physics I;	**Course No.:**	PHY C131;
Date:	15-10 -09;	**Weightage:**	8%;
Duration.:	20 minutes;	**Max Marks:**	24

1. The mass per unit length of a thin rod of length **l** varies with the distance **x** from one end as $\rho = \rho_o x^2 / l^2$. Find the total mass of the rod. (6)

2 A spaceship weighing 18000kg is moving with a speed of 1 kms^{-1} under the influence of zero gravity. The rocket engine eject gas at a constant rate of 150 kgs^{-1} with a speed of 1500 ms^{-1} relative to the spaceship. Find the velocity of the spaceship after 1minute, assuming that rocket gives an acceleration in the direction of the initial velocity of the spaceship. (6)

3. A batman with mass 91 Kg jumps straight down from a bridge into a boat of mass 510Kg in which a criminal is fleeing. The velocity of the boat is initially 11m/s. What is the velocity of the boat after Batman lands in it? (6)

4. A 0.25 kg ball moving in the + x direction at 13m/s is hit by a bat. Its final velocity is 19m/s in the –x direction. The bat acts on the ball for 0.010s. Find the average force exerted on the bat by the ball and vice versa. (6)

Rough Work