# BITS PILANI, DUBAI CAMPUS
# KNOWLEDGE VILLAGE
# DUBAI

## I-YEAR I- SEMESTER
## COMPREHENSIVE EXAM- MAKEUP PAPER

**COURSE TITLE:** PHYSICS I; **COURSE NO.:** PHY UC131;
**MAXIMUM MARKS:** 80; **DURATION:** 3 HOURS

**Q I. Each of the following questions or a part carries 2 MARKS.**

(i) Photon A has twice the energy of photon B.
   a. Is the momentum of A less than, equal to, or greater than that of B?
   b. Is the wavelength of A less than, equal to, or greater than that of B?

(ii) In the photoelectric effect (for a given target and a given frequency of the incident light), which of these quantities, if any, depend on the intensity of the incident light beam: (a) the maximum kinetic energy of the electrons, (b) the maximum photoelectric current, (c) the stopping potential, (d) the cutoff frequency?

(iii) For a wave function representing a matter wave, if the product of the wave function and its complex conjugate is constant along a given direction in space. What does it signify?

(iv) White light is made to pass through
   a. A prism
   b. A diffraction grating
   Draw the spectrum and its order in both the cases.

(v) For a given diffraction grating, does the least difference $\Delta\lambda$ in two wavelengths that can be resolved increase, decrease, or remains the same as the wavelength increases?

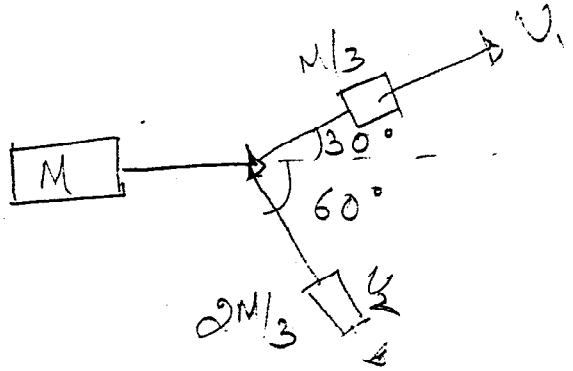
(vi) For a given wavelength region, is $\Delta\lambda$ greater in the first order or in the third order?

**Each of the following carries 4+4=8 MARKS.**

**Q II.** **A)** An iceboat is coasting along on a frozen lake. Friction between the ice and the boat is negligible, and so is air resistance. Nothing is propelling the boat. From a bridge someone jumps straight down and lands in the boat, which continues to coast straight ahead. **(a)** Does the horizontal momentum of the boat change? **(b)** Does the speed of the boat increase, decrease, or remain the same? Explain.

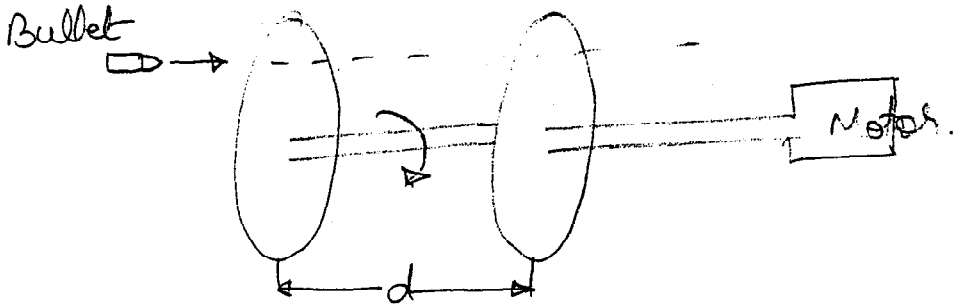
**B)** A block of ice of mass 200 kg is sliding on a frozen lake with a speed of 50 m/s. It comes across an obstruction and breaks into two pieces of masses $1/3^{rd}$ and $2/3^{rd}$. They fly off with velocities $v_1$ and $v_2$ as shown. **(a)** What is the magnitude of $v_1$ and $v_2$? **(b)** What is the speed and direction of the center of mass

before and after the explosion? (c) What are the velocities $v_1$ and $v_2$ in the center of mass frame?



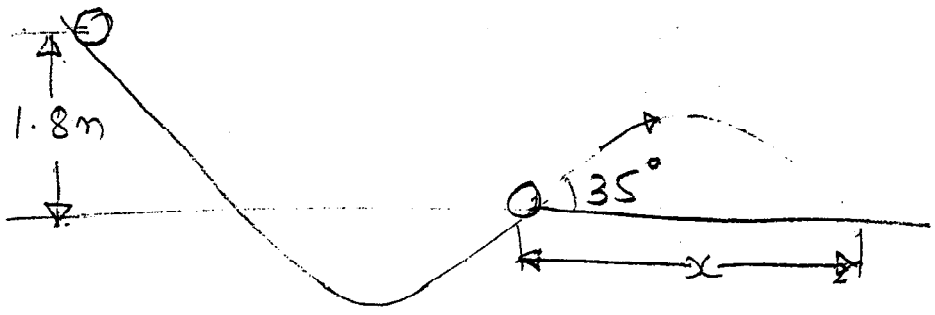

**Q III. A)** Two identical carts, starting from rest, accelerate side-by side along a straight track. The wheels on one of the cars roll without slipping, while the wheels on the other slip during part of the time. **(a)** Which car is the winner? For the car whose wheels roll without slipping, is there **(b)** a relationship between its linear speed and the angular speed of its wheels? Explain.

**B)** The figure shows a device that can be used to measure the speed of a bullet. The device consists of two rotating disks, separated by a distance of d=0.85 m, rotating with an angular speed of 95 rad/s. The bullet first passes through the left disk and then through the right. It is found that the angular displacement between the two bullet holes is $\theta = 0.24$ rad. Determine the speed of the bullet.



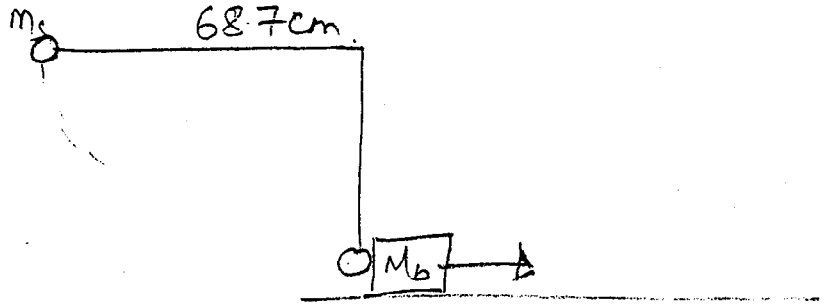

**Q IV. A)** Two spheres one hollow and the other solid have same radius. They are both rotating with same angular speed and possess equal mass. **(a)** Which sphere has greater moment of inertia and why? **(b)** Which sphere has smaller angular acceleration? Suddenly a net external torque is applied to both. **(c)** Which sphere takes longer to come to a halt? Explain.

**B)** A tennis ball, starting from rest, rolls down the hill in the figure. At the end of the hill the ball becomes airborne, leaving at an angle of 35° with respect to the ground. If the ball is treated as a thin walled spherical shell, determine the range x.



**Q V.** **A)** A shopping bag is hanging straight down from your hand. **(a)** If you and the bag are a system and everything else is the environment, what is the work done and who is doing it in the following cases (Is the work external or internal?)? **(i)** You walk on a level floor with the bag. **(ii)** You lift the bag to your head. **(b)** What would be the situation if the Earth also becomes the part of the system for the two cases?

**B)** A steel ball of mass 0.514 kg is fastened to a cord 68.7 cm long and is released when the cord is horizontal. At the bottom of its path, the ball strikes a 2.63 kg steel block initially at rest on a frictionless surface as shown in the figure. On collision, one-half the mechanical kinetic energy is converted to internal energy and sound energy. Find the final speeds.




**Q VI.** **A)** With the help of an example show that critical damping is necessary in our life. Only with the help of diagrams, distinguish between Light damping, Critical damping and Over damping in a system.

**B)** A mass $m$ hangs vertically on the end of a light spring that has spring constant k and is attached to a fixed point. A force proportional to the speed of the mass damps vertical oscillations of the mass. At time zero a vertical driving force F acts the mass on. If $m$ = 0.02 kg, $k$ = 20 N/m, the Q-factor is 80, and a driving force $F = 0.02\cos(55t) \times \cos(5t)$ N is applied, find the displacement of the mass as a function of time in the steady state.

**Q VII.** **A)** **(a)** A wave moves on a string with constant velocity. Does this mean that the particles of the string always have zero acceleration? Justify. **(b)** One end of each of two identical strings is attached to a wall. Each string is being pulled tight by someone at the other end. A transverse pulse is sent traveling along one of the strings. A bit later an identical pulse is sent traveling along the other string. What, if anything, can be done to make the second pulse catch up with and pass the first pulse? Account for your answer.

**B)** Determine the relationship between the group velocity and the phase velocity $v_p$ for the following types of waves, given the variation of $v_p$ with wavelength $\lambda$:

a. Small-wavelength waves on the surface of water controlled by surface tension, for which $v_p = a\lambda^{-1/2}$;
b. Transverse waves on a rod, for which $v_p = a\lambda^{-1}$;
c. Radio waves in an ionized gas, for which $v_p = \sqrt{(c^2 + b^2\lambda^2)}$;
d. Attenuated waves on a string, with a dispersion relation given by eqn. $\omega^2 = (k^2 - \alpha^2)\frac{F}{\rho}$.

**Q VIII. A)** Why does light disperse over double or multiple slits? How can we increase this dispersion? How is this dispersion different from dispersion due to prism? Explain.

**B)** A thin film of gasoline floats on a puddle of water. Sunlight falls almost perpendicularly on the film and reflects into your eyes. Although the sunlight has all the colors, the film has a yellow hue because destructive interference eliminates the blue color ($\lambda = 469$ nm) from the reflected light. The refractive indices of the blue light in gasoline and water are 1.4 and 1.33, respectively. Determine the minimum nonzero thickness $t$ of the film.

**Q IX. A)** Explain how could the study of a heating body bring about the concept of photons? Does the whole spectrum of electromagnetic waves behave both as particle as well as wave? Explain.

**B)** Assume that the position of an object is known so precisely that the uncertainty in the position is only $\Delta y = 1.5 \times 10^{-11}$ m. **(a)** Determine the minimum uncertainty in the momentum of the object. Find the corresponding minimum uncertainty in the speed of the object, if the object is **(b)** an electron (mass = $9.1 \times 10^{-31}$ kg) and **(c)** a Ping-Pong ball (mass = $2.2 \times 10^{-3}$ kg).