| **Problems set # 2** | **Physics 411** | September 20 , 2006 |
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1. Argentina rocked tournament hosts France with a sensational 17-12 victory in the opening match of the 2007 Rugby World Cup in Paris. The inspired Pumas outplayed an error-ridden and nervous-looking France and took control with a first-half try from full-back Ignacio Corleto. Centre Felipe Contepomi chipped in with 12 points to leave the 80,000-strong Stade de France crowd stunned. France could only muster four penalties from struggling fly-half David Skrela. At the kick-off the ball went up with a velocity $v_0$ and in a direction making an angle $\alpha$ with the horizontal. Calculate the time required for the ball to cross a line passing through the center of the half-way line and making an angle $\beta < \alpha$ with the horizontal. Assume the ball leaves the foot at ground level, and ignore air resistance and rotation of the ball.

2. (i) If the coefficient of static friction between a block sliding down an inclined plane is $\mu_s = 0.4$, at what angle $\theta$ will the block start sliding if it is initially at rest? (ii) After the block begins to slide, the coefficient of kinetic friction becomes $\mu_k = 0.3$. Find the acceleration for an angle of $30°$.

3. Neglecting air friction, estimate: (i) How long it took King Kong to fall straight down from the top of the Empire State Building (380 m high), (ii) and his velocity just before "landing." (ii) Find the expressions for the displacement and velocity which correct the previous approximation by considering a retarding force proportional to the velocity. (iii) Taking a retarding force constant $k = 0.05$, estimate the percentage correction on the velocity of Kong after 2 seconds.

4. A mouse of mass $m$ jumps on the outside edge of a freely turning ceiling fan of moment of inertia $I$ and radius $R$. By what ratio does the angular velocity change?

5. Early test flights to the space shuttle used a "glider" (mass 980 kg including pilot) that was launched horizontally at 500 km/h from a height of 3500 m. The glider eventually landed at a speed of 200 km/h. (a) What would its landing speed have been in the absence of air resistance? (b) What was the average force of air resistance exerted on it if it came in at a constant glide of $10°$ to Earth?

6. A jet fighter pilot knows he is able to withstand an acceleration of $9\,g$ before blacking out. The pilot points his plane vertically down while traveling at Mach 3 speed and intends to pull up in a circular maneuver before crashing into the ground. (a) Where does the maximum acceleration occur in the maneuver? (b) What is the minimum circle the pilot can take?

7. A particle moves in a medium under the influence of a retarding force equal to $mk(v^3 + a^2 v)$, where $k$ and $a$ are constants. Show that for any value of the initial speed the particle will never move a distance greater than $\pi/2ka$ and that the particle comes to a rest only for $t \to \infty$.