THE UNIVERSITY
of LIVERPOOL

1.

(a) State the laws of friction.

A piece of ice slides down a 30^{o} rough incline in twice the time it takes to slide down a 30^{o} smooth incline. What is the coefficient of kinetic friction between the ice and the rough incline? **[10]**

(b) State the conditions necessary for a rigid body to be in static equilibrium in an inertial frame.

A man of mass 90 kg stands on a level bridge a quarter of the way from one of the bridges ends. The bridge is uniform with a total mass of 400 kg. Determine the values of the vertical forces exerted on each end of the bridge by its supports. **[10]**

(c) Write down the expressions for the translational and rotational kinetic energy of a body moving with speed v and rotating with angular speed ω.

A uniform sphere of radius r = 0.1 m and mass m = 1 kg is released from rest and rolls, without slipping, a distance of 10 m down to the bottom of a 30^{o} incline. Calculate the speed of the sphere at the bottom of the incline and the time taken to reach the bottom. (The moment of inertia of a uniform sphere is $I = \frac{2}{5}mr^2$.) **[10]**

(d) State the parallel axis theorem.

A metre rule of mass m = 0.5 kg is suspended vertically from a smooth peg inserted in a small hole drilled at the 0.9 m mark. When displaced the period of oscillation is 1.57 seconds. Use this observation to determine the moment of inertia about the point of suspension. Calculate the period when the ruler is suspended from the 0.6 m mark. (You may assume the formula $T = 2\pi\sqrt{\frac{I}{mdg}}$.) **[10]**

(e) State the conditions necessary for the application of Bernoulli's equation, $p_1 + \frac{1}{2}\rho v_1^{\,2} + \rho g h_1 = p_2 + \frac{1}{2}\rho v_2^{\,2} + \rho g h_2$.

A model submarine has wings which are 3 cm long and 2 cm wide. They are shaped such that water has to flow a distance of 2.4 cm when travelling over the wing's lower surface and 2.1 cm when flowing over its upper surface. What is the down-force that the wings generate through the Bernoulli effect when the submarine is submerged and travelling at 0.2 m/s? The density of water is 1000 kg/m^3. **[10]**