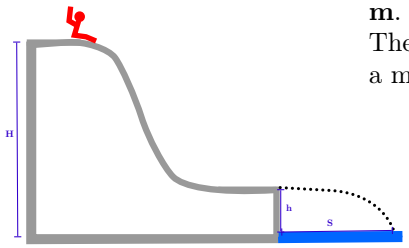
Instructions: Assume g = 9.8 m/s^2. Show all your work. Exam Duration: 2.5 hrs. Good luck!

River Crossing

A boat moves relative to water with a velocity that is **n = 2.0** times less than the river flow velocity. The distance between the opposite banks is **d = 130 m**. The river flows at **v = 18 km/h**

- At what angle to the stream direction must it move to minimize drifting? [5]
- How long (rounded to the nearest minute) does it take to cross the river? [2]
- Show that if GPS is off by 3.8°, it drifts along the bank by **130 m** when it finishes crossing. [3]

Water Slide

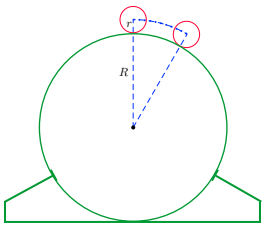


A girl starts sliding from rest, down a smooth water slide from a height of **H = 6 m**. The slide has a horizontal portion (base) at height **h** above the pool surface. The horizontal distance of the free flight is **s** as shown. Safety regulations require a minimum pool length of $\ell = 1.5 \times \mathbf{s}$

- What value of **h** will maximize distance **s** of the girl's motion in air? [4]
- How long is she in air? [2]
- What is the safe pool length ℓ? [2]
- Her dad weighs four times as much. Can he land safely in water? [2]

Ball Rolling

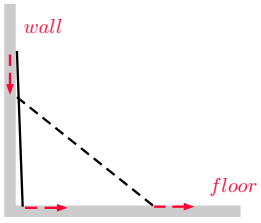
A uniform sphere of radius **R = 20.0 cm** fixed to a base. A ball of radius **r = 4.0 cm** and **m = 0.1 kg** starts rolling from it's top. Assume the ball's moment of inertia about it's center of mass, $I_{cm} = (2/5)mr^2$ and it does not slip.



- What is it's angular velocity as it breaks off the sphere? [5]
- What is angle with respect to vertical at that instant? [3]
- If it slid (instead of rolled), would this angle be smaller, larger or equal? [2]

Sliding Ladder

A uniform ladder of length ℓ rests against a smooth wall and and is held motionless on a smooth floor (but only just) such that the bottom is almost up against the wall. When released, the bottom end slides away from the wall and the top end slides down the wall.



- Show the trajectory of center of mass is circular [3]
- When it loses contact with the wall what is the horizontal component of the velocity of center of mass? [5]
- Show that the normal force is maximum when the angle between the ladder with the wall is 26.7°. [2]

HINT: Normal force from the wall is zero when released and when it loses contact with the wall. Somewhere in between these two instants, it reaches a maximum.