**Problem 1: Multiple choice [20 pts]**

*For each of the following questions, circle the letter corresponding to the best answer from the options given. No partial credit will be given. You do not need to show your work, although you are welcome to use the space on the page for scratch paper.*

a) [5 points] You hook a taut rope to a treasure chest at the bottom of a lake. The chest remains at rest on the lake floor. What is the correct free-body diagram for the treasure chest?

- A.  
  \[ \vec{F}_{\text{tension}} \]
  \[ \vec{F}_{\text{buoyant}} \]
  \[ \vec{F}_{\text{friction}} \]
  \[ \vec{F}_{\text{gravity}} \]
  \[ \vec{F}_{\text{normal}} \]

- B.  
  \[ \vec{F}_{\text{tension}} \]
  \[ \vec{F}_{\text{gravity}} \]
  \[ \vec{F}_{\text{normal}} \]

- C.  
  \[ \vec{F}_{\text{tension}} \]
  \[ \vec{F}_{\text{buoyant}} \]
  \[ \vec{F}_{\text{normal}} \]

- D.  
  \[ \vec{F}_{\text{tension}} \]
  \[ \vec{F}_{\text{buoyant}} \]
  \[ \vec{F}_{\text{friction}} \]
  \[ \vec{F}_{\text{gravity}} \]
  \[ \vec{F}_{\text{normal}} \]

b) [5 points] Which one of the following statements is true for a completely enclosed fluid?

- a) *Any change in pressure applied to the fluid produces a change in pressure elsewhere in the fluid, which depends on direction.*
- b) *The pressure at all points in a fluid is independent of any pressure applied to it.*
- c) *Any change in applied pressure produces an equal change in pressure at all points within the fluid.*
- d) *An increase in pressure in one part of the fluid results in an equal decrease in pressure in another part of the fluid.*
- e) *The pressure is the same at all points within the fluid?*

c) [5 points] The absolute pressure at a depth \( h \) below the surface of the ocean is \( 1.5 \ P_{\text{atm}} \), where \( P_{\text{atm}} \) is the atmospheric pressure. The absolute pressure at a depth \( 2h \) is then

- a) \( 2P_{\text{atm}} \)
- b) \( 3P_{\text{atm}} \)
- c) \( 4P_{\text{atm}} \)
- d) \( 6P_{\text{atm}} \)
- e) \( 9P_{\text{atm}} \)
d) [5 points] A roller coaster starts from rest on the far left of a track, as shown in the figure.

Which of the marked locations could the roller coaster be at some time $t$ later? (Choose all that apply; partial credit will be given.)

A. A  
B. B  
C. C  
D. D  
E. E

Problem 2: Cable guy [10 pts]

A rigid board is fixed to a wall by a hinge at one end and supported at the other end by a vertical cable, as shown. The cable has a radius of $r = 1$ cm, an unstretched length of $L = 2.5$ m, and a Young’s modulus of $E = 1 \times 10^9$ Pa. A person of mass $m = 75$ kg stands at the center of the board. The board itself has negligible mass. How far does the cable stretch to support the board and person in static equilibrium?
**Problem 3: Hey Mr. DJ [20 pts]**

The coefficient of static friction between a small coin (mass $m = 5$ g) and the surface of a turntable is $\mu_s = 0.50$. The turntable rotates at a constant angular speed of 50 rpm (revolutions per minute).

a) [7 pts] What is the maximum distance $R$ from the center of the turntable where the coin can sit without slipping?

b) [7 pts] You bring the turntable to a stop, set the coin at a distance $R = 10$ cm from the center, and accelerate the turntable with constant angular acceleration to an angular speed of 50 rpm. If this acceleration occurs over a duration of $t = 10$ s, through what angle $\theta$ has the coin rotated? Assume that the coin does not slip on the turntable.

c) [6 pts] During the acceleration described in part b) above, what is the work done by static friction on the coin?
Problem 4: Quarter-pipe [15 points]

You push a block \((m = 200 \text{ g})\) against a horizontal spring \((k = 200 \text{ N/m})\), compressing the spring a distance \(d = 15 \text{ cm}\). The block is on a frictionless surface. Beyond the equilibrium position of the uncompressed spring is a rough surface \((L = 60 \text{ cm})\) that has a coefficient of friction \(\mu_k = 0.3\). Following this surface is a frictionless curved ramp.

You let go of the block, which travels over the rough surface, and then up the ramp. What is the maximum height \(h\) that the block reaches on the curved ramp before turning around?