Mock exam 2
PHYS-101(en)
2 December 2025

Problem booklet

Problems

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Multiple Choice Questions (4 points)

Please clearly mark your selected answer from the options given below each problem.

1. In Figure 1, a force of magnitude F is applied to one end of a lever of length L. What is the magnitude of the torque about the point S?

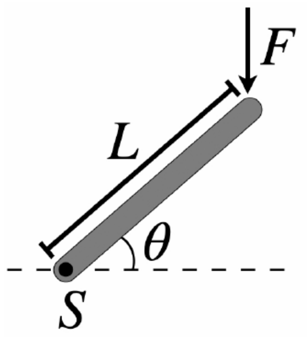

Figure 1: Torque about pivot point S.

   (a) FL
   (b) $FL\sin(\theta)$
   (c) $FL\cos(\theta)$
   (d) $FL\tan(\theta)$
   (e) None of the above.

2. Figure 2 shows the potential energy diagram for a particle undergoing one-dimensional motion between points "a" and "g". The total mechanical energy of the system E_m is indicated by the dashed line. At how many of the labeled points will the velocity be zero?

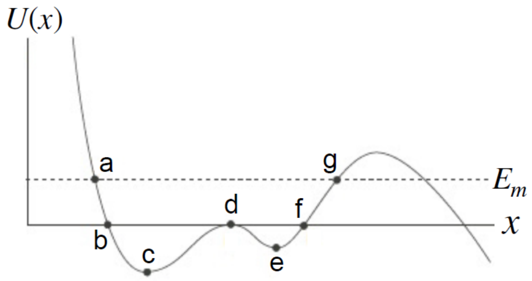

Figure 2: Potential energy diagram in one dimension.

   (a) 0
   (b) 1
   (c) 2
   (d) 3
   (e) 4

3. The greatest acceleration of the center of mass (CM) of the baseball bat in Figure 3 will be produced by pushing with a force F at:

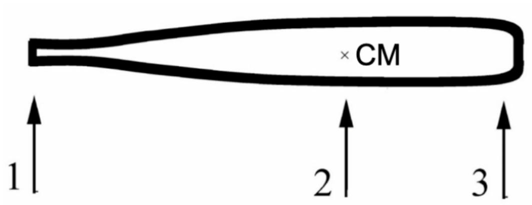

Figure 3: Force on a baseball bat.

(a) Position 1
(b) Position 2
(c) Position 3
(d) All positions are the same
(e) The CM does not accelerate

4. In the experiment shown in Figure 4, cart A rolls on a flat horizontal track to the right, away from the motion sensor installed at the origin and hits cart B elastically, which is at rest.

The graph below the experimental setup shows the distance from the motion sensor to cart A as a function of time. Which objects collide at $t = 1.5\,\text{s}$?

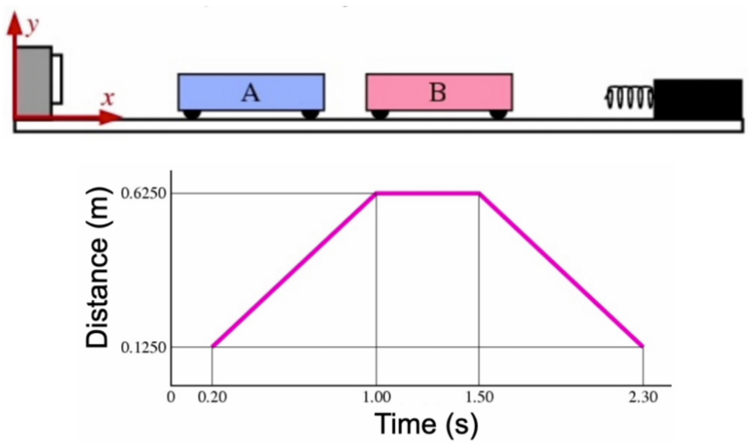

Figure 4: Colliding carts.

(a) Cart B and the spring
(b) Cart B and the motion sensor
(c) Carts A and B
(d) Cart A and the spring
(e) Cart A and the motion sensor

5. Big Air at the Winter X Games (10 points)

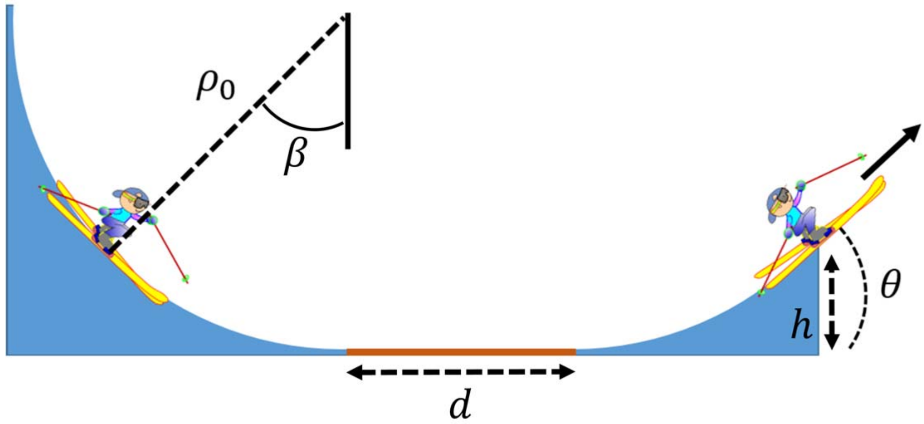

Figure 5: The proposed ski jump for the Big Air event.

This year, EPFL has been selected to host the Winter X Games, and you have been put in charge of designing the Big Air event! For this event, you propose a ramp similar to the one shown in Figure 5.

In your design, the skier of mass m begins at rest at the top of an icy (frictionless) curved ramp and descends under gravity. The initial descent is shaped as a quarter circle with a radius of ρ_0, guiding the skier from a vertical drop to horizontal motion. Immediately following this descent, the skier transitions to a flat horizontal section of total length d covered in rough snow, with a kinetic friction coefficient μ.

Following the flat part is a launch section covered in ice that redirects the motion of the skier upward. The takeoff height is h, and the angle (with respect to the horizontal) is θ.

The organizing committee wants you to answer the following questions about your proposed design (you can neglect air drag in all cases):

a) Verify that the work done by friction on the skier in the flat section is $W_f = -\mu\, m\, g\, d$.

Why is this quantity negative?

b) What is the minimum value of ρ_0 for the skier to barely make it across the flat part?

c) What is the minimum value of ρ_0 for the skier to barely reach the top of the ramp (height h in the launch section)?

d) If ρ_0 is sufficiently large for the skier to take off from the ramp, compute the maximum height that the skier will reach in the air as a function of the parameters of the problem.

e) What is the g-force experienced by the skier during the initial (circularly-shaped) descent? Write your answer as a function of the angle β (as defined in Figure 5). Note that the g-force is the magnitude of the force exerted by the surface on the skier, divided by the weight of the skier.

Where is the g-force largest?