RAJARATA UNIVERSITY OF SRI LANKA
FACULTY OF APPLIED SCIENCES

B.Sc. (General) Degree in Applied Sciences
First Year - Semester I Examination – May 2022

PHY 1201 – General Physics

Time: Two (02) hours

Take g = 9.81 m/s^2, P_{atm} = 1.01 × 10^5 Pa (Atmospheric pressure)

Answer ALL Questions

Provide detailed solutions to ensure total points.

Show force diagrams at all relevant places

Calculators will be provided

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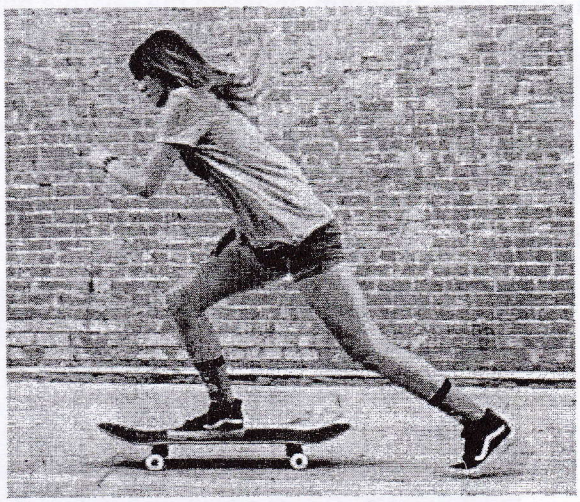
1. The image shows a skateboard rider is getting her skateboard into moving on the horizontal ground. The forces acting from the surrounding air are negligible.

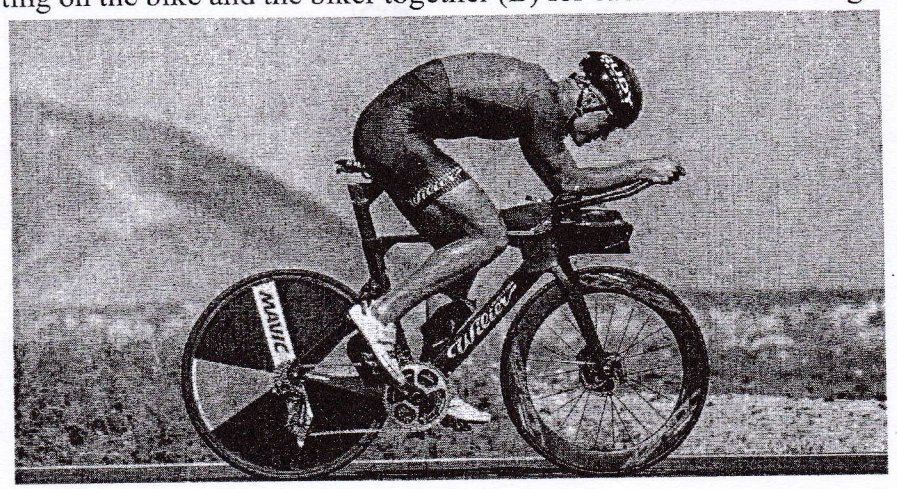


a) Draw a force diagram to indicate the forces acting on the skateboard and the rider together (S) for the situation shown in the diagram. Follow the standards in drawing and in labeling.

b) For each force in the force diagram, separately indicate its Newton's Third Law pair force

(8 marks)

2. A cyclist is moving from left towards the right. Draw force diagrams to indicate the forces acting on the bike and the biker together (B) for each of the following situations.



a) The bike is moving at constant speed on the flat ground. The biker is paddling
b) The bike is accelerating on the flat ground
c) The bike is cruising (the biker is not paddling) on the flat ground
d) The bike is moving uphill at constant speed
e) The bike is cruising downhill
f) The biker applies breaks and brings the bicycle to a halt (the drag force is not significant)

Drag force is significant in all the situations of the bike and the biker, except where it is mentioned as not significant.

- Follow the standards in drawing and in labeling forces
- If a certain practice is common for all force diagrams, just do it only once
- You do not have to write long force definitions. Use the two-letter notation
- In Each force diagram, indicate the relative magnitude of the forces

(16 marks)

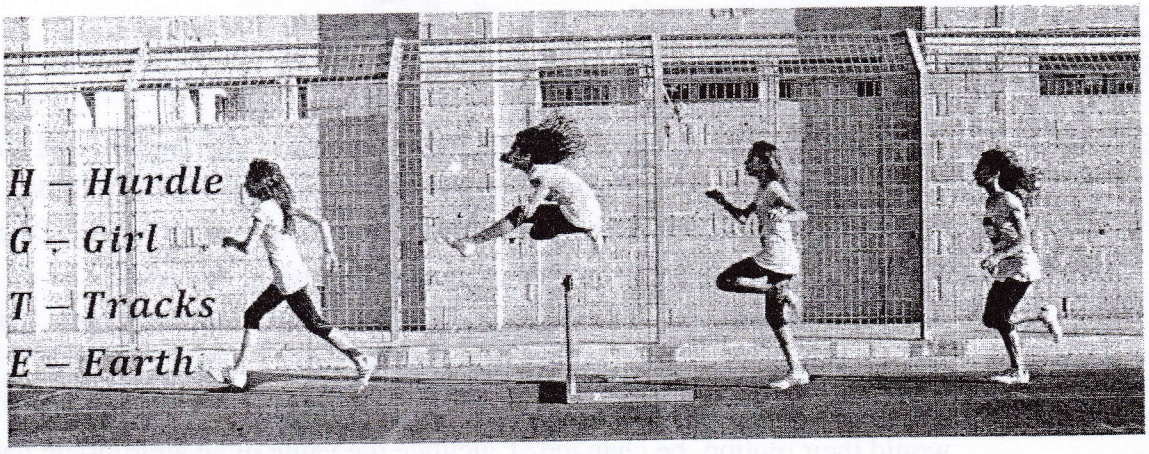
3. A man who weighs 80 kg with his backpack is standing still on the airport terminal moving walkway belt without receiving the support from the handrails. His shoes maintain a 0.2 coefficient of static friction with the moving belt. What is the maximum acceleration the belt can achieve before the man's feet attempt to slip along the belt?

(6 marks)

4. Write brief answers for the following two questions:
   a) What are the different types of forces acting on an object moving inside a fluid medium? Explain the conditions under which each category of force is significantly affecting the motion.
   b) Explain the reason the contact force is often called the normal force.

(5 marks)

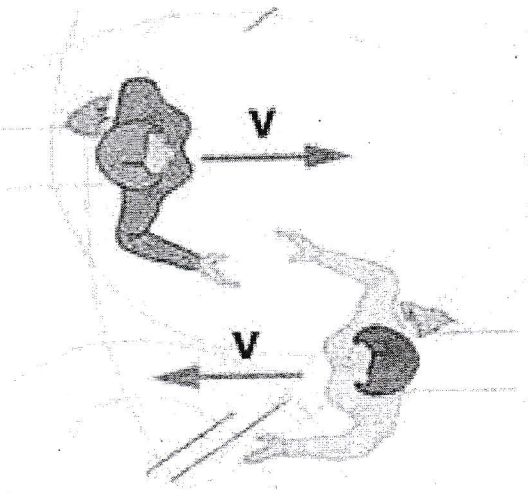
5. The series of images shows a young girl (G) of mass 60 kg clearing a 0.76 m high hurdle. While moving along the tracks the girl runs without slipping, and at the end of each stride (step) her alternative foot comes to be at steady contact with the tracks for a certain amount of time. Just before launching herself over the hurdle, she had a 0.15 s ground contact time. In the flight she carries her body 0.2 m above the hurdle and lands steadily on her feet at the other side. Right above the hurdle she has a horizontal speed. She covers a horizontal distance of 2.3 m in her flight.



   a) What is the speed and the direction of the girl when she launched herself to jump over the hurdle?
   b) The girl's spiked athletic shoes maintain a 0.8 coefficient of static friction with the running tracks. What is impact normal force just before the girl launched herself?
   c) Explain the relationship between the magnitudes of the normal force and the force due to gravity acting on the girl while she is running along the horizontal ground.

(15 marks)

6. Two figure skaters who are almost identical in their height and body mass (70 kg) move in opposite directions at the speed 2.5 m/s along parallel straight lines separated by the length of their extended arms. At the instant of passing each other, they reach out and tightly hold their hands keeping the hands fully stretched. Each hand extends 80 cm from their body centers.



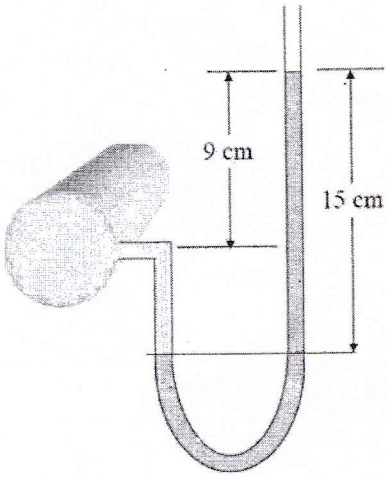
a) Explain the subsequent motion of the figure skaters. Use diagrams and mention the appropriate laws of physics that determines the nature of the motion
b) What is v_2, their linear speed immediately after locking their hands? Calculate the value and clearly indicate the law of physics that being applied.
c) What is ω_2, their angular speed immediately after locking their hands. Calculate the value and clearly indicate the law of physics that being applied?
d) If the two skaters would come closer by making a lock from their elbows how would their motion, be changed? Calculate the value of an appropriate parameter that you claim to change. Clearly mention the laws of physics that being applied. When the elbows are locked their separation reduces to a half of the value they had when the hands we stretched.
e) If the coefficient of static friction between their skating boots and the ice rink is 0.05, how long will they move before they gradually come to rest? Perform this calculation for the stretched arm configuration.

(20 marks)

7. A 9000 kg space satellite is moved from the surface of the earth to a 400 km above the surface of the Earth. The Earth can be approximated to a sphere of radius 6371 km and mass 6.0×10^{24} kg. The universal gravitational constant has the value 6.67×10^{-11} m^3 kg^{-1} s^{-2}, and the radius of the Earth is 6371 km.
a) How much work is required to move the satellite between the orbits?
b) What is the total work required to position the satellite in the new orbit? Think about the requirement to leave the satellite in the orbit without falling back to the Earth.

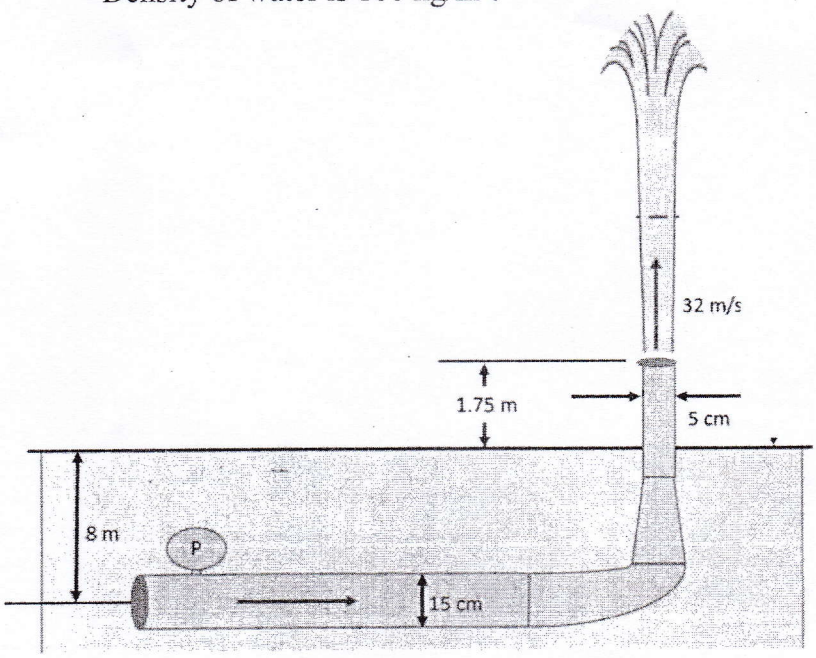
(15 marks)

8. One end of a simple U-tube manometer containing mercury connects to a horizontal pipe that carry oil of specific gravity 0.8. The other end of the manometer is open to the atmosphere. The specific gravity of mercury is 13.6. The open end of the manometer is 9 cm above the center of the pipe, and the mercury column at each side maintains a 15 cm height difference. What is the pressure of the oil in the pipe?



(5 marks)

9. A decorative water fountain is expected to produce a vertical jet of water coming out at 32 m/s speed from a 5 cm diameter pipe. The outlet is 1.75 m above the ground level. The design includes a 15 cm diameter horizontal pipe laid 8 m below the ground. Density of water is 100 kg/m^3.



a) What is P, the reading of the pressure gauge connected to the horizontal pipe?
b) What is H_{max}, the maximum height of the vertical water jet?

(10 marks)

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