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RAJARATA UNIVERSITY OF SRI LANKA
FACULTY OF APPLIED SCIENCES

B.Sc. (General) Degree in Applied Sciences
First Year - Semester I Examination – March 2021

PHY 1201 – General Physics

Answer ALL Questions **Time: Two (02) hours**

This exam is given to the students who had not completed the online course activities

Take g = 9.81 m/s^2

Provide detailed solutions to ensure total points.

Show force diagrams at all relevant places

Calculators will be provided

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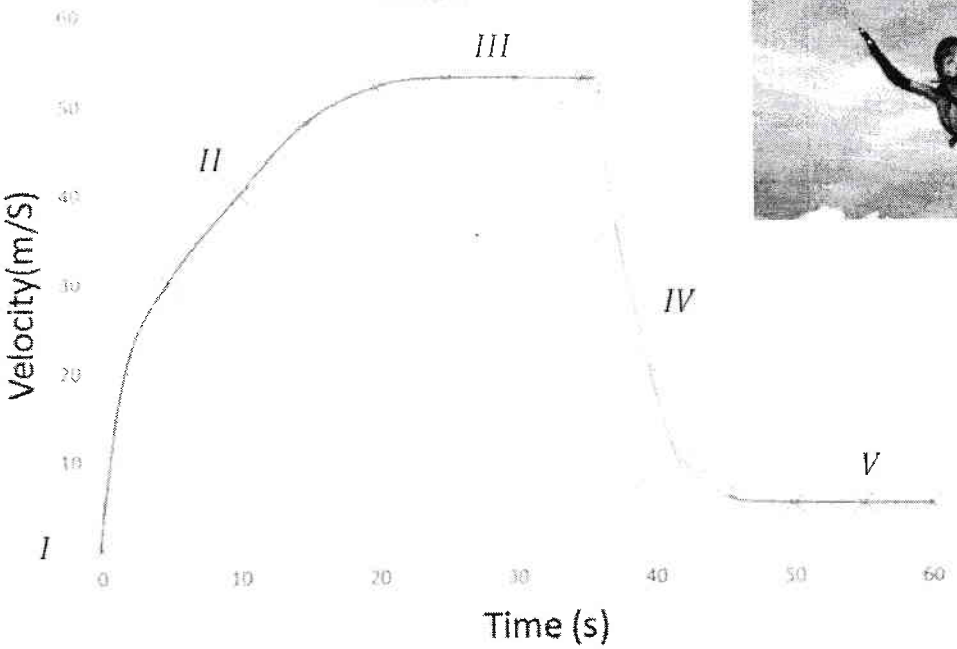
1. As shown in the image, a crate (C) is pushed by a man (M) along the surface of a ramp (R). The ramp makes an angle α with the flat ground. Assume that the box is moving up along the ramp. The force applied by the man acts parallel to the ramp.

Draw force diagrams to indicate the forces acting on the following system choices. Label the forces in the given notation. Follow the standards in drawing and in labeling.

a) The crate only
b) The man and the crate together

(8 marks)

2. The velocity versus time graph below indicates how the velocity of a skydiver (S) changed in the downwards direction after she was released from a stationary helicopter at t =0. The up-thrust on the skydiver is negligible. The downward direction is taken as positive for the graph.



During the period from 0s-36s the skydiver fell keeping her belly horizontal and over this period, her frontal cross-sectional area was 0.7 m^2. The skydiver's drag coefficient was approximately constant over the period from 0 s-36 s. The density of air is approximately 1.23 kg/m^3 and the mass of the sky diver is 70 kg.

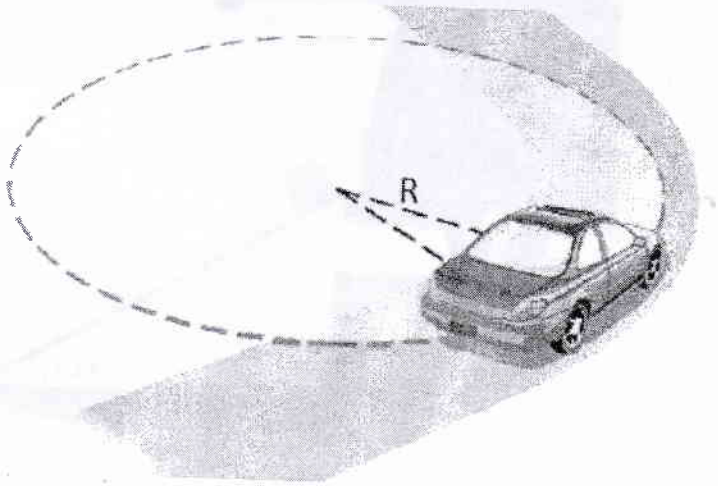
a) Provide an ordered list of the regions I, II, III, IV, and V marked in the graph, to order the magnitude of the acceleration of the skydiver from the largest value to the least, including its sign
b) Draw separate force diagrams showing the forces acting on the skydiver for the instants/intervals marked as I, II, III, IV, V, in this order. Show the relative magnitudes of the forces acting on the skydiver at each instant/interval.
c) What is $[\vec{F}_{D(A,S)}]$, the magnitude of the average drag force acting on the skydiver over the shaded region between 35 s and 46 s (interval IV) in the graph?
d) What is $C_{D1(S)}$, the drag coefficient of the skydiver when she falls flat on her belly?
e) What is the magnitude of the drag force from air on the skydiver over the interval marked as II?
f) Starting from 36 s, where it shows a sharp change in the graph, the frontal cross-sectional area of the skydiver increased to 22.3 m^2. Her speed between 50 s and 60 s was 5 m/s. What is $C_{D2(S)}$, the effective drag coefficient for the skydiver, for her motion starting from 36 s?

(20 marks)

3. As shown in the image, a 10 kg book (B) is pressed against a vertical wall(W) by applying a horizontal force of magnitude 100 N. The coefficient of static friction μ_s, between the block and the wall is 0.60, and the coefficient of kinetic friction, μ_k, is 0.40. Explain if the book would stay at rest or slide down the wall.

(6 marks)

4. A car of mass 900 kg is taking a flat circular curve of radius 25 m.



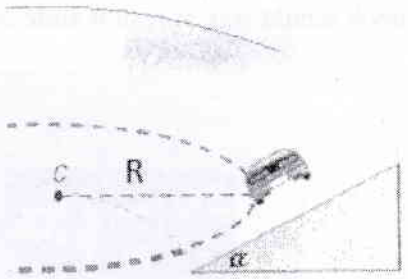
On a dry day $\mu_{f,s(max,dry)}$, the maximum coefficient of static friction between the tires and the road surface is 0.8. On a wet day $\mu_{f,s(max,wet)}$, the maximum coefficient of static friction reduces to 0.1.

a) What is $v_{max,dry}$, the maximum possible speed for the car to take the curve on a dry day?

b) What is $v_{max,wet}$, the maximum possible speed for the car to take the curve safely under wet conditions?

(10 marks)

5. **(Relate to Problem 4)** The local authorities rebuilt the flat curve with a 20^0 banking angle (angle from the flat ground), while having the same radius as before.

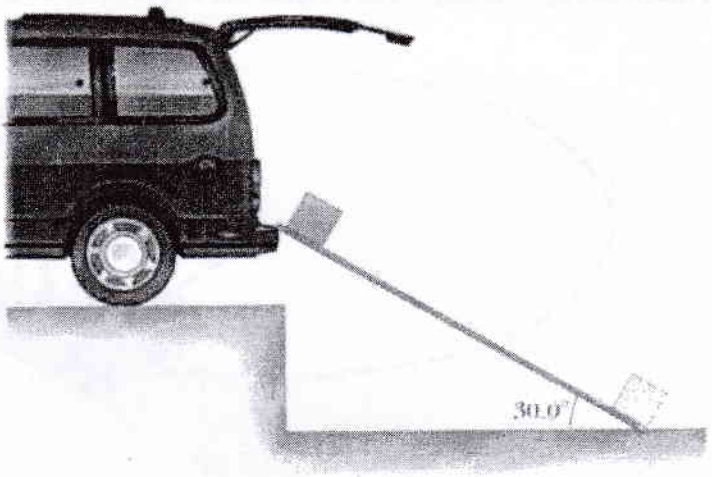


a) What is $|\vec{F}_{N2(R,Cr)}|$, the magnitude of the Normal force, applied by the car from the (banked) road?

b) If the same road surface conditions were maintained as in problem 4, what is $v_{max,dry2}$, the maximum possible speed that the car can take the banked curve on a dry day?

(10 marks)

6. A box (B) of mass 20 kg was brought down from a delivery van to the ground using a 2 m long ramp (R). The ramp is inclined to the flat ground by an angle of 30^0. The box experienced a friction force of magnitude 25 N from the ramp.



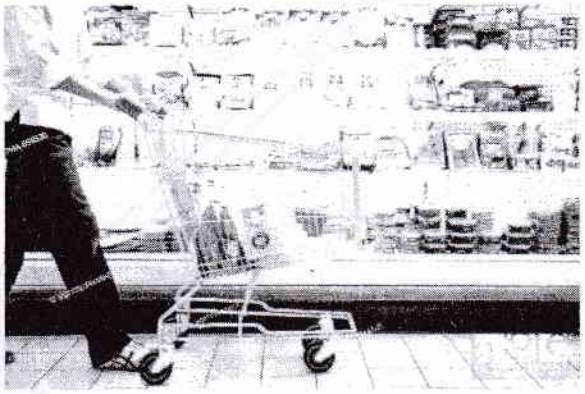
a) Draw a force diagram for the box (Ignore the effects from air on the box)

b) Using the definition of work done by an external force, comment and justify, for each external force acting on the box, whether their work is positive, negative, or zero.

c) Determine W_{tot}, the total work done on the box.

(10 marks)

7. A shopper (S) pushes a grocery cart (C) of mass 60 kg for a distance 20.0 m at a constant speed on level ground (G), against a 35.0 N frictional force. The shopper applies a force on the cart in a direction that makes 25^0 below the horizontal line.



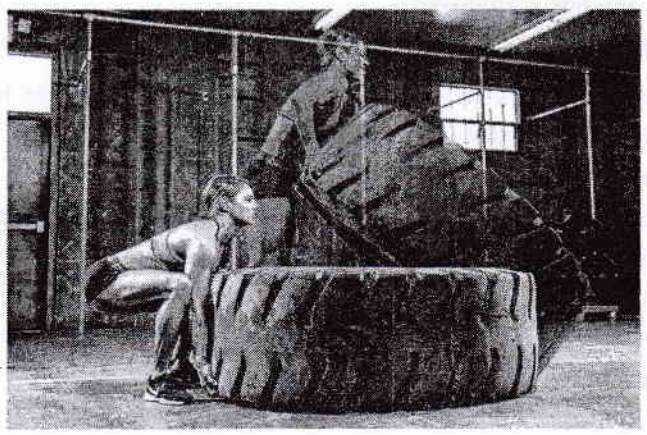
a) What is $W_{\vec{F}_{g(E,C)}}$, the work done by the gravitational force on the cart?

b) What is $\vec{F}_{app(S,C)}$ the work done by the force applied by the shopper on the cart?

c) What is $W_{tot(C)}$, the total work done on the cart?

(6 marks)

8. The image shows a CrossFit athlete (A) performing the flipping of tire exercise. The 50 cm wide tire (T) has a mass of 250 kg and a diameter of 152 cm. At the beginning the tire stays on the flat ground of the gym and the athlete applies a vertical force below the bottom surface of the tire at the edge of the tire as shown in the figure. The center of gravity of the tire coincides with the center of the tire.

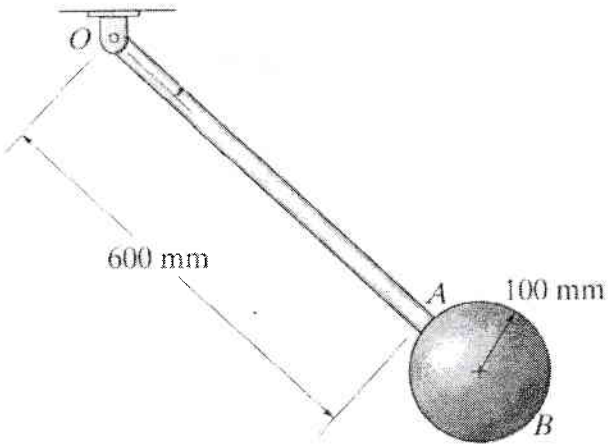


a) What is $|\vec{F}_{app(A,T)}|$, the magnitude of the minimum force that the athlete should apply for the tire to start flipping around the other end of the diameter as shown?

b) After flipping the tire, the athlete holds it such that the bottom surface of the tire is making a 30^0 angle with the flat ground. What is $|\vec{F}_{app2(A,T)}|$ the magnitude of the force the athlete should apply perpendicular to the bottom surface of the tire, to hold the tire in this orientation?

(10 marks)

9. A solid sphere of mass 15 kg is rigidly fused to a solid rod of mass 10 kg. The free end of the rod is pivoted to the ceiling as shown in the image below.



a) What is I_{total}, the total moment of inertia of the rod and the sphere system around a horizontal axis passing through the pivot point A perpendicular to the plane of the paper?

b) What is R_g, the radius of gyration of the total system about the same axis?

c) This system can turn around the pivot point friction-free. What is $|\vec{\alpha}_{0(system)}|$, the magnitude of the initial angular acceleration in rad/s^2, of the rod and the sphere system around the pivot point, if it was released from rest keeping the rod horizontal?

d) What is $|\vec{\alpha}_{45^0(system)}|$, the magnitude of the angular acceleration of the rod and the sphere system around the pivot point, when the rod has turned making a 45^0 angle with the horizontal line?

e) What is $|\vec{\alpha}_{90^0(system)}|$, the magnitude of the angular acceleration of the rod and the sphere system around the pivot point when the rod has turned making a 90^0 angle with the horizontal line?

f) What is T_s, the period of small angular oscillations this system would eventually undergo around the vertical line that pass through the pivot point?

g) What is T_p, the period of the small angular oscillation of a simple pendulum that has the same moment of inertia as the sphere-rod system around its pivot point, and connected to the ceiling through a string of length equal to the radius of gyration of the sphere-rod system around the pivot point?

(20 marks)

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