



UNIVERSITY OF RUHUNA

Faculty of Engineering

End-Semester 2 Examination in Engineering: December 2018

Module Number: ME2201

Module Name: Engineering Mechanics (N/C)

[Three Hours]

[Answer all questions, each question carries 10 marks]

Clearly state any assumptions that you may make. Take $g = 9.8 \text{ N/kg}$

- Q1.**
- i) Using the definitions of work (W) and kinetic energy (E_K) for 1D motion of a particle, derive equation of work and energy: $W = \Delta E_K$ [2.5 Marks]
- ii) A bicyclist is riding her bicycle at a constant speed of 18km/h and suddenly applies the brakes to stop at in front of a wall. Distance to the wall before apply the brakes is 5m and the reaction time (thinking to action) of the bicyclist is 0.1 seconds.
- a). Calculate the speed (V_0) of the bicycle just before her hits the wall if the deceleration of the bicycle due to the braking is given by $0.1v^2$ where v is the speed of the bicycle measured in m/s .
- b). Assume her head is rigid (4kg in mass) and that it has constant deceleration as it travels through the 50mm thickness of the bicyclist helmet, and her releases the brakes just before the hit (See Figure Q1(ii)). Determine the deceleration and force on the helmet due to the collision neglecting force from the neck on the head. [7.5 Marks]
- Q2.**
- i) Figure Q2(i) shows a particle moving in a curvilinear path. The particle is at A at time t and it moves to a position A' after a short time δt . The radius of curvature of the path A to A' can be approximated to ρ with the center at C and small angle of rotation is represented by $\delta\beta$ in radians.
- a). Copy the diagram to your answer script and sketch the motion of the particle in normal (n) and tangential (t) coordinate plane. Taking the unit vectors in n and t directions are \underline{e}_n and \underline{e}_t , derive the velocity vector and the acceleration vector of the particle in $n - t$ coordinates and show their directions.
- b). Sketch the resultant acceleration of the particle above in $n - t$ coordinate plane when accelerating and decelerating. [5 Marks]

(continues to next page...)

- ii) To anticipate the dip and hump in the road, the driver of a car applies her brakes to produce a uniform deceleration. Her speed is 90 km/h at the bottom A of the dip and 45 km/h at the top C of the hump, which is 120 m along the road from A. If the passengers experience a total acceleration of 3.2 m/s^2 at A and if the radius of curvature of the hump at C is 150 m, calculate
- the radius of curvature ρ at A,
 - the total acceleration at the inflection point B, and
 - the total acceleration at C.

[5 Marks]

- Q3. i) Describe a motion of a ball moving under the gravitational acceleration (g) when its velocity in horizontal and vertical directions are v_x and v_y respectively.

[2 Marks]

- ii) A projectile is fired with a speed of $v \text{ m/s}$ at an angle of β° . A second projectile is then fired from the same position at an angle of $\theta^\circ (< \beta^\circ)$ with the same speed and t_0 seconds later.

- Determine a relationship between β and θ of the second projectile so that the two projectiles collide at one point in the space.
- Using the relationship obtain above (a), calculate t_0 when $v = 60$, $\theta = 57.6$ and $\beta = 60$.
- Determine the position of the collision (x, y) with respect to the initial position for the data given in above (b).

[8 Marks]

- Q4. i) Obtain a relationship for propulsion force (Q) vs. time (t) of a vehicle moving on a rough inclined plane of angle α and surface friction coefficient μ at the vehicle's maximum power of P_{max} . Given that initial velocity of the vehicle is u (at $t = 0$) and deceleration of the vehicle is a constant.

[4 Marks]

- ii) The mine car C of total mass M is being pulled up on the smooth inclined plane of angle ϕ using the motor M and the rope-and-pulley arrangement shown in Figure Q4(ii). If the angular speed of motor drum is $\omega \text{ rpm}$, radius of the drum is r and the motor operates at its maximum power,

- Draw the force diagram of the car.
- Determine the speed at which a point P on the cable must be traveling toward the motor.
- Determine the speed of the car (v).
- Obtain the tension of the rope attached to the car.

[6 Marks]

- Q5 i) Define the term linear momentum and derive an expression for the linear impulse - momentum principle for system of particles as

$$G_1 + \int \sum F(t)dt = G_2$$

in usual notations. Hence obtain conditions to have conservation of linear momentum for a system of particles.

[3.5 Marks]

- ii) The loaded 150kg cart is shown in Figure Q4(b) is moving downwards on the given ramp of 30° at 4 m/s. A force P is applied to the cable as shown at time $t = 0$ and P is increased uniformly with the time until it reaches 600 N at $t = 4$ seconds, after which time it remains constant at this value.

a). Draw the impulse-moment diagram and plot the P vs. t

b). Calculate the time at which the skip reverses its direction

c). Determine the velocity of the skip at $t = 8$ seconds.

[6.5 Marks]

- Q6 i) Define and explain the term “Degree of Freedom (DoF)” related to rigid body motion.

[1 Marks]

- ii) Name and describe four main types of rigid-body plane motions with suitable sketches. Determine degree of freedom and clearly mention one example for each type of motion.

[4 Marks]

- iii) Briefly describe the meaning of a kinematic pair related to machine. Name one kinematic pair from each category: 1DoF, 2DoF and 3DoF.

[2 Marks]

- iv) The Scotch-York mechanism is shown in Figure Q6(iv). If the pin is fixed at R m distance from the wheel center and the wheel rotates at angular speed of ω rad/s ,

a). Obtain a relationship between vertical displacement (x) of point, P at the bottom of the York and ω .

b) Determine the velocity and the acceleration of P.

[3 Marks]

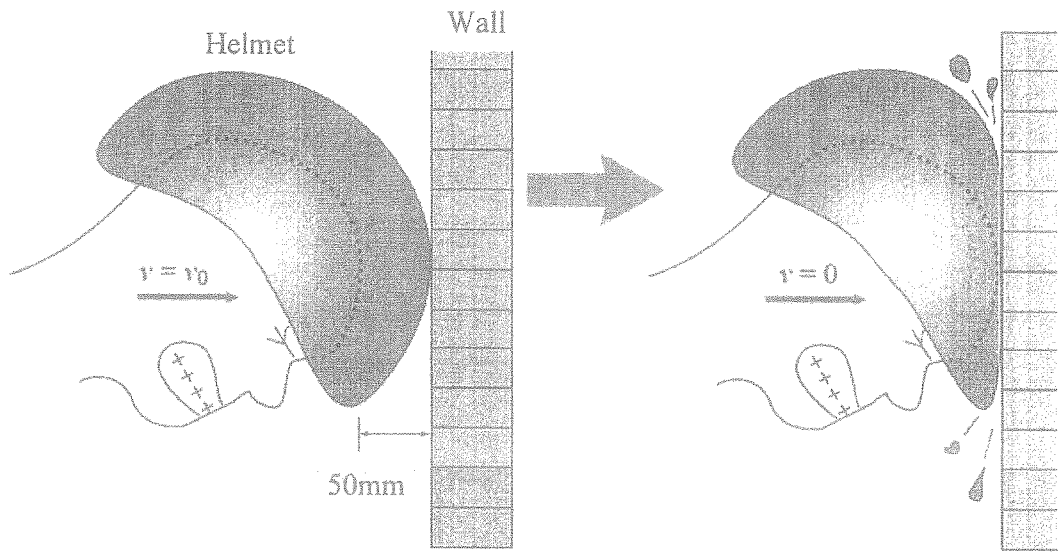


Figure Q1(ii)

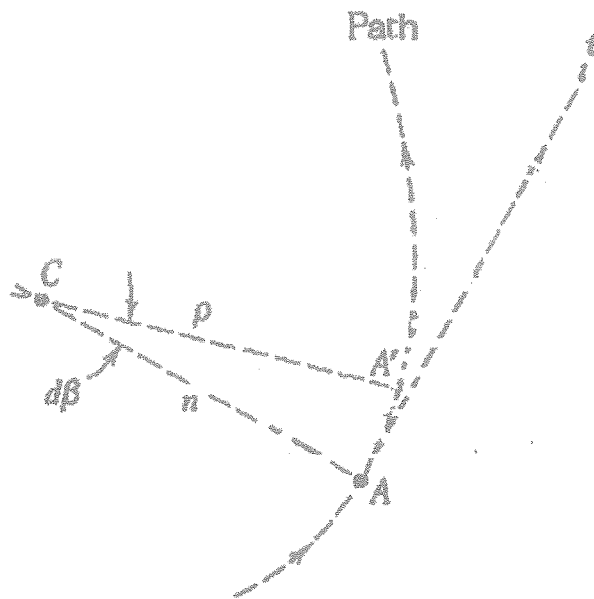


Figure Q2(i)

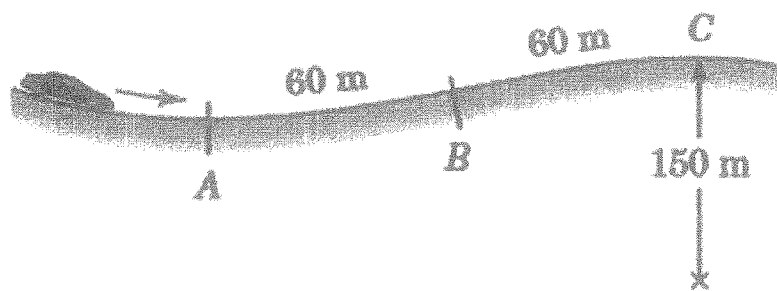


Figure Q2(ii)

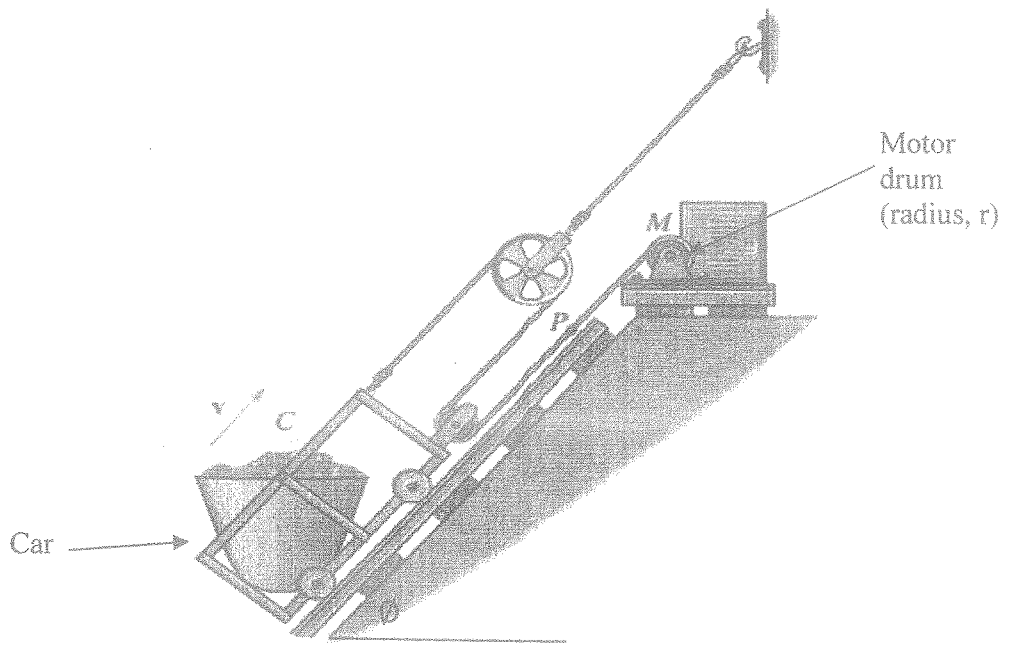


Figure Q4(ii)

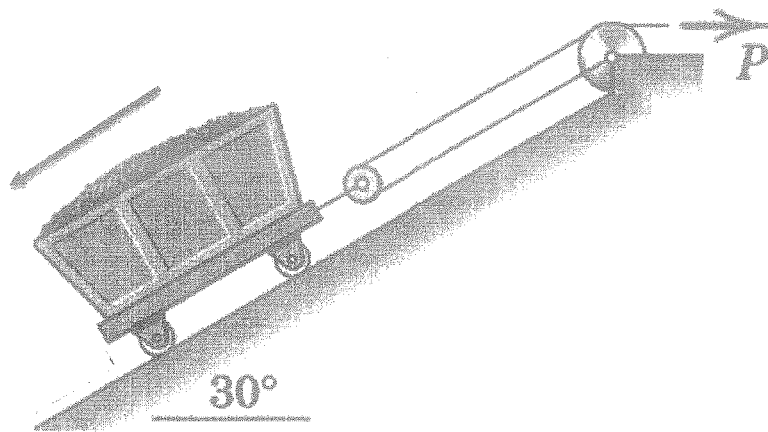


Figure Q5(i)

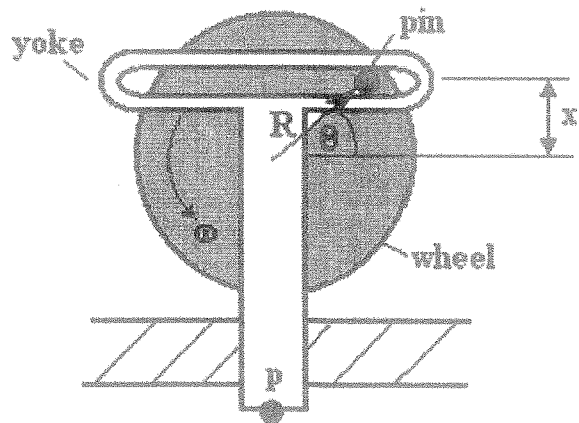


Figure Q6(iv)