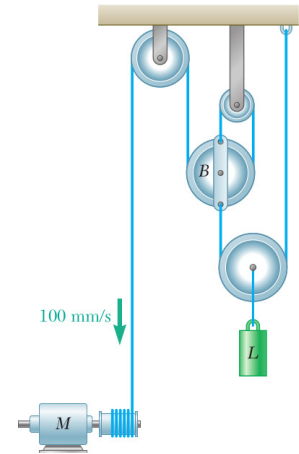


Problem Set 2

Due: 1 June 2017, 12.30 p.m.

Problem 1. The motor M reels in the cable at a constant rate of 100 mm/s . Determine (a) the velocity of load L , (b) the velocity of pulley B with respect to load L .

(1 + 1 marks)



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Problem 2. A particle is launched horizontally, close to the Earth's surface, with initial speed $v(0) = v_0$. Find both the normal and tangential components of acceleration at an instant $t > 0$. Neglect air drag.

Use a geometric argument to relate these components to the Cartesian components of velocity.

(4 marks)

Problem 3. A river flows eastwards, parallel to the banks, with the speed of the flow depending on the distance $0 \leq y \leq L$ from the southern bank as

$$v_2(y) = v_0 \sin \frac{\pi y}{L},$$

where v_0 is a positive constant and L is the river's width. A canoe is crossing the river with constant velocity \mathbf{v}_1 (with respect to the water), oriented perpendicularly to the direction of the stream. Find

- (a) the velocity of the canoe with respect to the bank, and its magnitude,
- (b) the canoe's trajectory,
- (c) and the distance the canoe has drifted down the river.

(1 + 4 + 1 marks)

Problem 4. The trajectory of a particle moving in the xy -plane is given by the parametric equations

$$x(t) = bt^2, \quad y(t) = -ct^2,$$

where b and c are positive constants (what are their units?). Find

- (a) parametric equations of the trajectory in the polar coordinate system,
- (b) implicit equation of the trajectory in both coordinate systems,
- (c) velocity and acceleration in both systems.

(1 + 1 + 3 marks)

Problem 5. Motion of a particle is given by parametric equations in polar coordinates

$$r(t) = r_0(1 - ct), \quad \varphi(t) = \frac{ct}{1 - ct},$$

where c and $r_0 > 0$ are constants (what are their units?).

Find

- (a) the implicit equations of the particle's trajectory (use a computer to plot it),
- (b) velocity of the particle (transverse and radial components) and speed,
- (c) as well as its acceleration (transverse and radial components).
- (d) Comment on the motion in cases when $c > 0$ and $c < 0$.

(1 + 3/2 + 3/2 + 1 marks)

Problem 6. The oscillation of rod OA about O is defined by the relation $\varphi = \frac{3}{\pi} \sin \pi t$, where φ and t are expressed in radians and seconds, respectively. Collar B slides along the rod so that its distance from O is $r = 6(1 - e^{-2t})$ where r and t are expressed in centimeters and seconds, respectively.

- (a) What are the units of the numbers in the formulas?

When $t = 1$ s, determine (b) the velocity of the collar, (c) the acceleration of the collar, (d) the acceleration of the collar relative to the rod.

(1 + 3/2 + 3/2 + 1 marks)

