

- (a) The circuit in Figure 1.(a) contains a cell of emf E , a known variable resistance R_0 , an unknown resistance R and an ammeter. When X and Y are short circuited $E = I_0 R_0$. When R is inserted the current is αI_0 , where α is a constant.

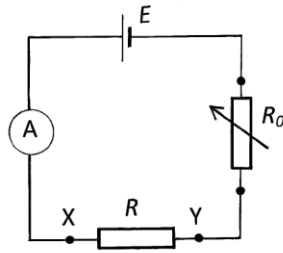


Figure 1.(a)

- (i) Express R in terms of R_0 and α , giving the range of validity of R and α .
- (ii) In order to extend the range of α , modify the circuit by putting R in parallel with R_0 . Determine the ranges of R and α for the modified circuit.

[4]

- (b) A man, on an open wagon of a train travelling along a straight horizontal track at a constant speed of 10 ms^{-1} , throws a ball into the air in line with the track, that he judges to be at 60° to the horizontal. A woman standing on the ground observes the ball rise vertically.

How high does the ball rise relative to

- (i) the man and;
- (ii) the woman?

[5]

(c) A glass block of refractive index $\mu = 1.5$ has an 'L' cross-section, Figure 1.(c), and is of constant width and thickness.

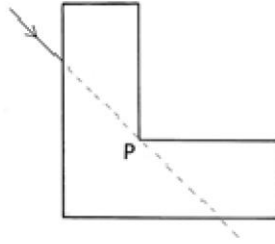


Figure 1.(c)

- (i) A laser beam enters the block from the left, as indicated in Figure 1.(c), at an incident angle of $\theta = 45^\circ$. If the block was absent the beam would pass through the point P. Determine the angle at which the beam will emerge from the bottom face after refraction through the block.
- (ii) If this beam enters the block below the horizontal through P, determine its possible subsequent path(s).

[6]

(d) The largest moon of Jupiter, Ganymede, revolves around the planet in a circular orbit of radius 1.07×10^6 km and period 7.16 days. Determine the mass of Jupiter, M_J , in terms of the mass of the Earth, M_E .

The radius of the Earth $R_E = 6.38 \times 10^6$ m

[5]

(e) Two 1.00 m lengths of wire, one copper and one tungsten, are joined vertically end to end. The copper wire has a diameter of 0.500 mm. When a 100 kg block is suspended from one end, the combined length of wire stretches by 6.00 cm. What is the diameter, d , of the tungsten wire if the Young's modulus for copper is 12.4×10^{10} Pa, and that for tungsten is 35.5×10^{10} Pa?

[6]

- (f) Wood from the coffin of an Egyptian mummy showed a specific activity of $1.2 \times 10^2 \text{ s}^{-1}\text{kg}^{-1}$. Comparable living wood has a value of $2.0 \times 10^2 \text{ s}^{-1}\text{kg}^{-1}$. The half life of carbon-14 is 5.70×10^3 years. What is the time interval, T_B , in years, since the burial?

[5]

(g) Explain why the centre of gravity of a triangular plate lies along a median; the line joining a vertex to the midpoint of the opposite side. An equilateral triangular plate, sides of length b , has a triangle, formed by two corners and the centre of gravity of the original plate, removed. Determine the centre of gravity of the remaining plate. The centre of gravity of a triangular plate is at a point two thirds along the length of a median measured from the vertex.

[7]

- (h) A vertical U-tube, partially filled with liquid, is accelerated vertically upwards in a lift, acceleration α . What is the effective value of ' g ', g_v ? If the U-tube is mounted in a vehicle accelerating in a horizontal straight line, acceleration a , Figure 1.(h), what is the effective ' g ', g_h ? Express a in terms of the distance between the arms of the U-tube, L , and the difference in heights, h , of the liquid in the arms.

[7]

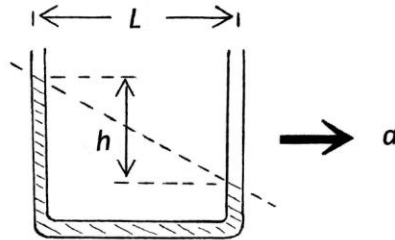


Figure 1.(h)

- (i) In Figure 1.(i) a fixed mirror, a light source and a light receiver are all 0.30 km from a rotating mirror, with angular frequency ω . The distance between the light source and the receiver is 0.60 m. What is the lowest value of ω required for detection of the reflected light?

[4]

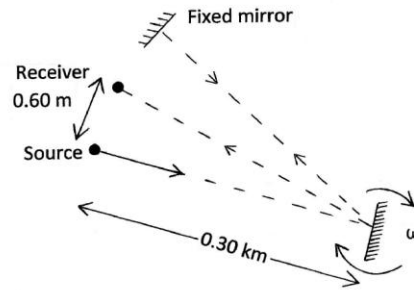


Figure 1.(i)

(j) A car travelling at 90 km/hr in a straight line sounds its horn continuously, frequency 400 Hz, as it passes a stationary observer. At the closest point, A, to the observer the car is at a distance $D = 100$ m from the observer. Determine the frequency heard by the observer when the car is:

(i) at A;

(ii) at a distance x from A, after passing A

The velocity of sound is $v_s = 343 \text{ ms}^{-1}$.

[8]

(k) A ball of mass m and velocity u collides elastically with a larger ball of mass M , initially at rest. The ball of mass m rebounds along its original line of motion with speed v_1 and the ball of mass M has velocity v_2 in the direction of u .

(i) Write down the conservation equations for the system.

(ii) Deduce the result that $u - v_1 = v_2$.

[5]

- (I) A velocity selector, Figure 1.(I) , consists of two slotted discs mounted on a common axis a distance d apart. The slots are displaced relative to each other by an angle θ . The axis is driven at an angular velocity ω . Particles in a horizontal beam, with all possible velocities, will get through the first slit, in the first disc, for a short time interval. To subsequently get through the second slit, particles must travel a distance d in the times it takes the second slot to line up with the beam. This will occur, for rotations of the second slit of $\theta, 2\pi+\theta, 4\pi+\theta, \dots$ etc.

If $d = 1.00$ m, $\omega = 24,000$ rpm and $\theta = 60^\circ$, what are the speeds of those particles that pass through the velocity selector?

[5]

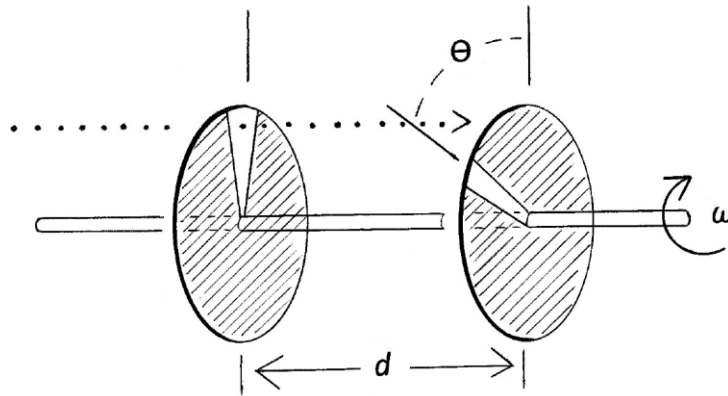


Figure 1.(I)