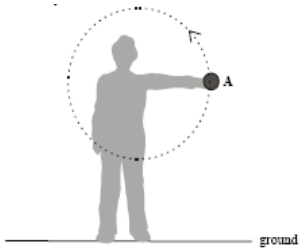
State Examination Commission – Physics Higher Level, 2006

Question 6

Define (i) velocity, (ii) angular velocity. (12)
Derive the relationship between the velocity of a particle travelling in uniform circular motion and its angular velocity. (12)

A student swings a ball in a circle of radius 70 cm in the vertical plane as shown. The angular velocity of the ball is 10 rad s^{-1}



What is the velocity of the ball? How long does the ball take to complete one revolution? (9)

Draw a diagram to show the forces acting on the ball when it is at position A. (6)

The student releases the ball when is it at A, which is 130 cm above the ground, and the ball travels vertically upwards. Calculate

(i) the maximum height, above the ground, the ball will reach;
(ii) the time taken for the ball to hit the ground after its release from A. (17)

(acceleration due to gravity = 9.8 m s^{-2})

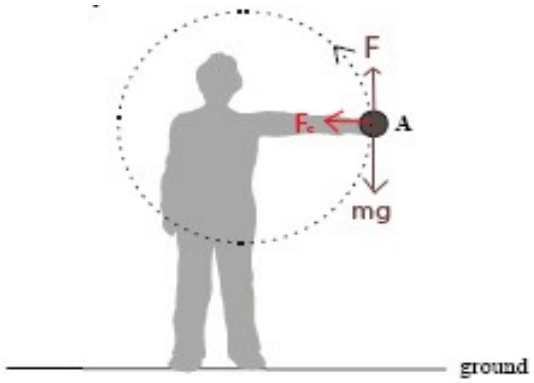
Define (i) velocity, (ii) angular velocity. (12)
Derive the relationship between the velocity of a particle travelling in uniform circular motion and its angular velocity. (12)

Standard definition/derivation – **must** be learnt

A student swings a ball in a circle of radius 70 cm in the vertical plane as shown. The angular velocity of the ball is 10 rad s^{-1}
What is the velocity of the ball? How long does the ball take to complete one revolution? (9)

$v = r\omega$
$= 0.70 \times 10$
$= 7.0 \text{ m s}^{-1}$

$T = 2\pi/\omega$
$= 2\pi/10$
$= 0.63 \text{ s}$



Draw a diagram to show the forces acting on the ball when it is at position A. (6)

mg = weight of ball
F = Applied force
F_c = centripetal force (caused by friction between fingers and ball)

The student releases the ball when is it at A, which is 130 cm above the ground, and the ball travels vertically upwards. Calculate

(i) the maximum height, above the ground, the ball will reach;
(remember to adopt a sign convention, say, up as positive, down as negative)

At max height, v = 0 ms^{-1}
Also, u = 7.0 ms^{-1} , and a = -9.8ms^{-2}. (acceleration due to gravity is *always* downwards)

$v^2 = u^2 + 2as$
$0 = (7)^2 + 2(-9.8)\,s$
$s = 2.5 \text{ m}$

=> max. height = 2.5 + 1.30 = 3.8 m

(ii) the time taken for the ball to hit the ground after its release from A. (17)

When the ball strikes the ground its displacement from A is s = -1.30 m. (It's displaced downwards)

$s = ut + \frac{1}{2}at^2$

$-1.30 = 7t - \frac{1}{2}(9.8)t^2$

Solving the quadratic for t, yields

$t = 1.59$ s