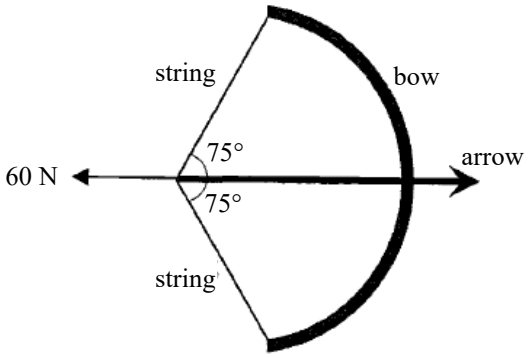
NSS Physics
Mechanics – Projectile Motion of Archery

Name : _____ Class :_____ ( ) Date:_____

1. A bow and arrow is a kind of projectile weapon. The string of a bow is drawn taut by a hunter with a force of 60 N and an arrow of mass 0.2 kg is held stationary as shown in Figure 1.1.

Figure 1.1



(a) (i) Find the tension of the string. Neglect the weight of the arrow. (2 marks)

(ii) Estimate the energy stored in the taut string if the initial speed of the arrow is 45 m s^{-1} when released. Assume that the bow is rigid and neglect the mass of the string. (2 marks)

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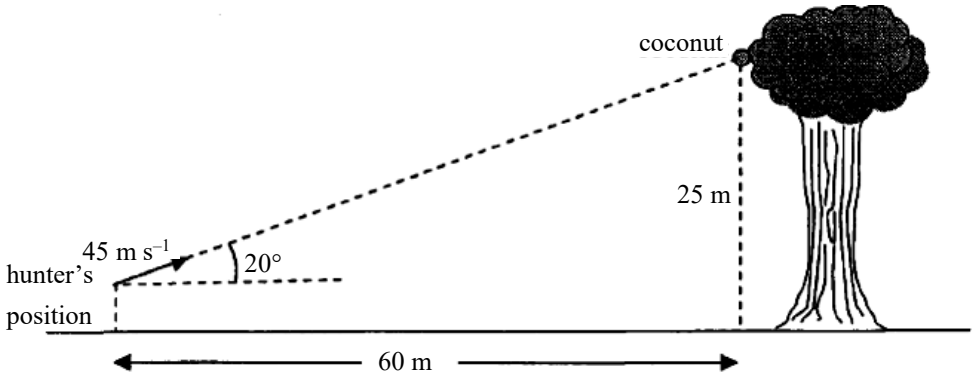
*(b) The hunter stands at about 60 m away from a tree as shown in Figure 1.2. He uses the bow to release the arrow in order to shoot a coconut held by a monkey (not shown in the figure) in the tree. The coconut is at a height of 25 m from the ground. The hunter aims directly at the coconut and the arrow leaves the bow at a speed of 45 m s^{-1} making an angle of 20° to the horizontal. At the moment the hunter releases the arrow, the monkey drops the coconut such that it falls vertically from rest. Neglect air resistance and the arrow's size. (g = 9.81 m s^{-2})

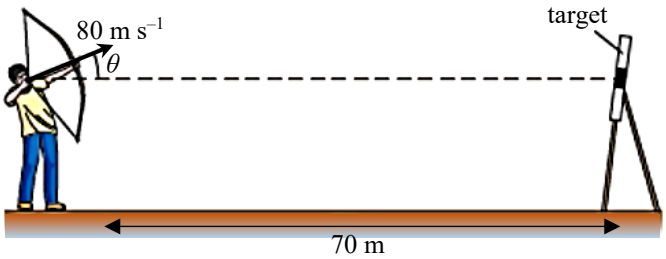
Figure 1.2



(i) Find the time taken for the arrow to hit the coconut. (2 marks)

(ii) Find the height of the coconut from the ground at the moment the arrow hits it. (2 marks)

2. In the Olympic archery competition, a target is set at a distance of 70 m away from the players. Suppose player A is able to release an arrow with a speed of 80 m s^{-1} at the same level of the bulleye of the target.



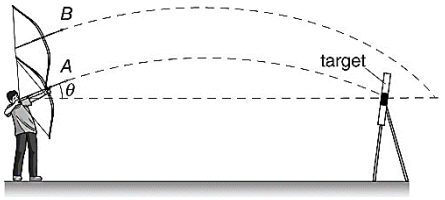
(a) To hit the bulleye, what angle of projection θ (Given: $\theta \leq 45°$) should the player A set ? (Given: $2\sin\theta\cos\theta = \sin 2\theta$) (3 marks)

(b) If player A changes the bow so that the arrow can be released with a higher speed, how should the answer in (a) be changed? Justify your answer. (1 mark)

(c) Player B who is taller than player A can release an arrow with a speed of 80 m s^{-1}. Compared with the answer in (a), how should his aiming point be changed? Justify your answer. (2 marks)

Marking scheme for projectile motion of archery:

Q1	Solutions	Marks
(a)(i)	Let T be the tension. $2T\cos 75° = 60$ $T = 116$ N	 1M 1A
(a)(ii)	Energy stored in the string = K.E. of arrow $= \frac{1}{2}(0.2)(45)^2$ = 202.5 J	 1M 1A
(b)(i)	$d = v\cos 20° \, t$ $60 = 45\cos 20° \, t$ $t = 1.42$ s	 1M 1A
(b)(ii)	$h = 25 - \frac{1}{2}gt^2$ $h = 25 - \frac{1}{2}(9.81)(1.42)^2$ $h = 15.1$ m [or h = 14.9 m]	 1M 1A

Q2	Solutions	Marks
(a)	Take upwards and rightwards as positive. Consider the vertical direction. By $s_y = u_y t + \frac{1}{2} a_y t^2$, $0 = (80 \sin \theta)t + \frac{1}{2}(-9.81)t^2$ $T = 16.3 \sin \theta$ Consider the horizontal direction. $s_x = u_x t$ $70 = (80 \cos \theta)(16.3 \sin \theta)$ $\sin 2\theta = 0.1073$ $2\theta = 6.16°$ $\theta = 3.08°$	 1M 1M 1A
(b)	The angle θ should be smaller.	1A
(c)	 With all conditions being the same, B's arrow would travel a longer horizontal distance s_x when reaching the same level as the bullseye as shown above. To reduce s_x, the angle of projection θ should be smaller.	 1A 1A