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MIDDLETON GRANGE SCHOOL
LEVEL 2 LINEAR AND PROJECTILE MOTION
PROGRESS TEST APRIL 2015

$v = \frac{\Delta d}{\Delta t}$ $a = \frac{\Delta v}{\Delta t}$ $v_f = v_i + at$ $d = v_i t + \frac{1}{2} at^2$ $d = \frac{v_i + v_f}{2} t$ $v_f^2 = v_i^2 + 2ad$ g=9.8ms^{-2}

QUESTION ONE: KINEMATICS. The 100m sprint [NZIP 2005]

Mary is at the start of her 100m sprint race. She is at rest and, at the firing of the starting gun; she accelerates for 4.0s up to her sprinting speed. She travels 19.2 m while accelerating.

(a) Calculate Mary's acceleration.

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_____

_____ Acceleration = _____

(b) Calculate the speed Mary attains after these first 4.0 seconds.

_____

_____ Speed = _____

Mary runs the rest of the race at a constant velocity and records a time of 12.8s.

(c) Calculate this constant velocity.

_____

_____

_____ Velocity = _____

Mary breaks the tape and then slows down from a velocity of 8.8ms^{-1} to a stop in 6.0s.

(d) How far did Mary run while she was slowing down?

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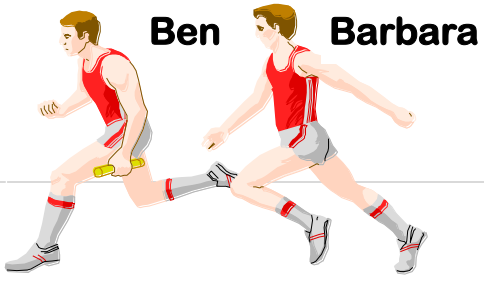
_____

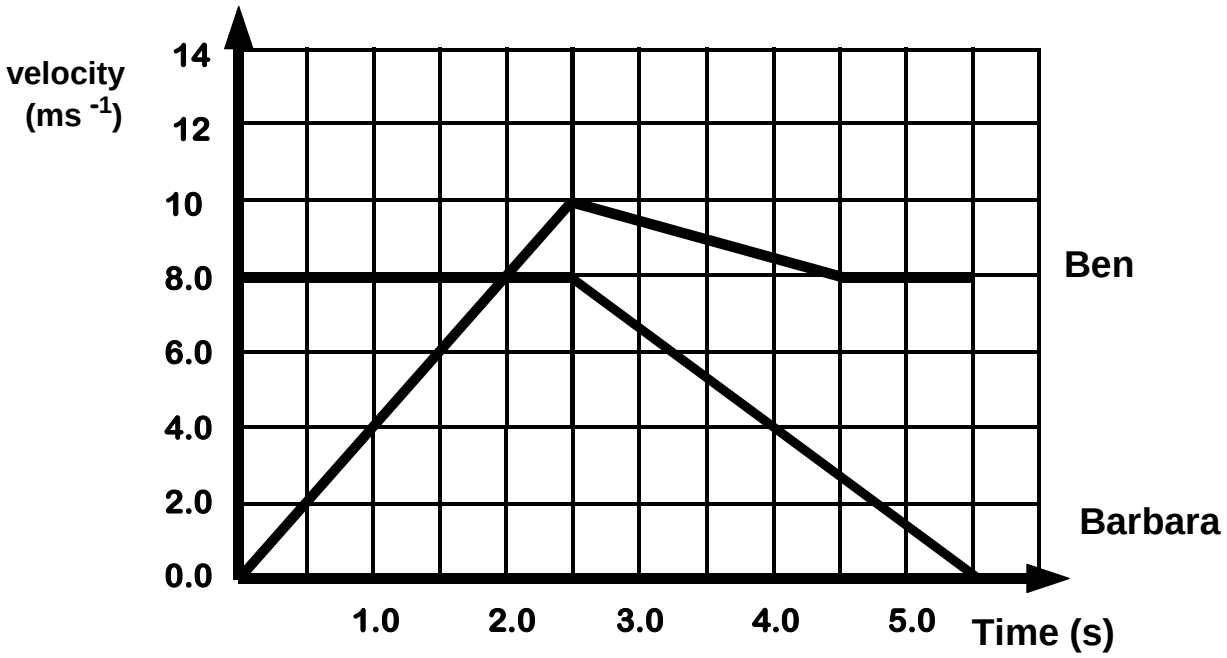
_____ Distance = _____

QUESTION TWO: MOTION GRAPHS. Changing the relay baton [NZIP 2005 Q4]



Barbara and Ben are members of the relay team. The velocity-time graph shown below shows the motion of both runners from the time when Ben starts to run and receives

the baton from Barbara, until Barbara slows to a stop at 5.5s. The runners are at the same position on the track at 2.5s.



(a) Calculate Ben's acceleration in the first 2.5s.

_____

_____ Acceleration = _____

(b) Show that the distance Ben moved in the first 2.5s was 12.5m.

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_____

(c) Determine how far Ben was in front of Barbara when she first started to move.

_____

_____

_____

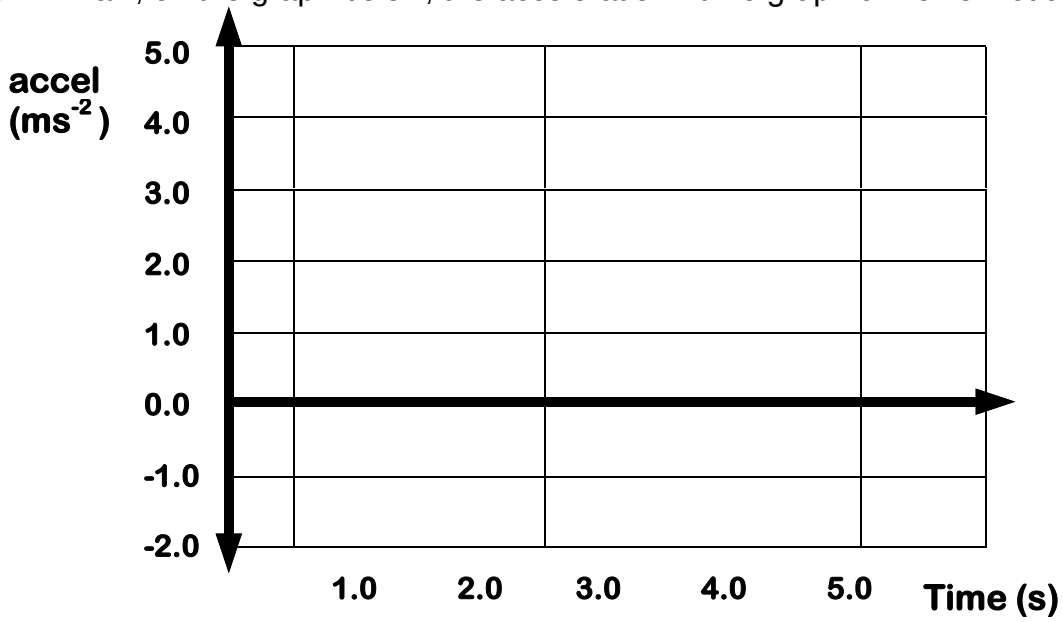
_____ Distance in front = _____

(d) Calculate Barbara's average velocity over the complete motion shown.

_____

_____ Average velocity = _____

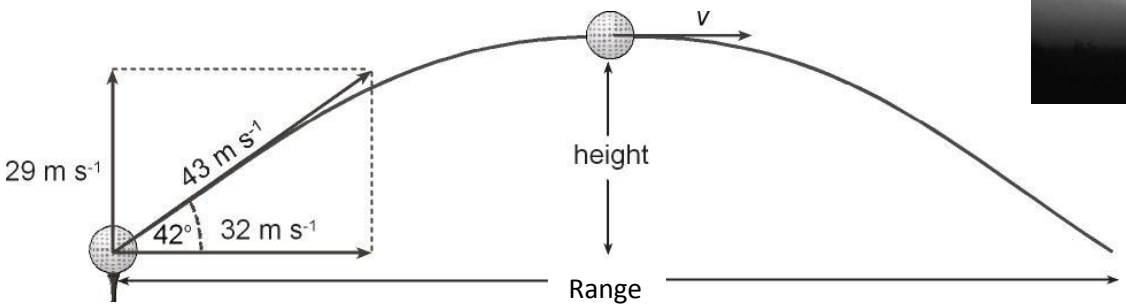
(e) Draw, on the graph below, the acceleration - time graph of Ben's motion.



QUESTION THREE: PROJECTILE MOTION [NZIP 2007 Q3]

Hannah is a golfer. She hits a golf ball. The diagram below shows the flight of the golf ball, which leaves the tee at a speed of 43 m s^{-1} at an angle of 42° to the horizontal direction.

You can assume there is no air resistance. Acceleration due to gravity = 9.8 m s^{-2}.



(a) Show that the **horizontal component** of her **initial velocity** is 32 m s^{-1}.

_____

_____

_____

(b) Show that the **vertical component** of her **initial velocity** is 29 m s^{-1}.

_____

_____

(c) Determine the **speed** *v* of the golf ball at the highest point. **Explain your reasoning**.

_____

_____

_____

(d) State the **size** and **direction** of the golf ball's **acceleration** at the highest point.

Size: _____

Direction: _____

(e) Calculate the **maximum vertical height** of the golf ball's flight.

_____

_____

_____

_____

_____

(f) Calculate the **time of flight** of the golf ball.

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_____

(g) After such a bad shot, Hannah decides to throw her golf ball vertically upwards into the air. Describe and explain what happens to the velocity and acceleration of the ball while it is in the air.

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ANSWERS: https://www.youtube.com/watch?v=HYuS4btgapo

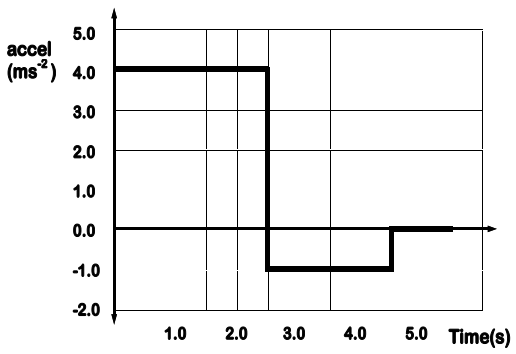
Question	Evidence	Achievement	Merit	Excellence
ONE (a)	$d = v_i t + \frac{1}{2} a t^2$ $19.2m = 0 + \frac{1}{2} \times a \times 4.0s^2$ $\therefore a = \frac{2 \times 19.2m}{4.0s^2} = 2.4ms^{-2}$		[2] Correct substitution, rearrangement and calculation.	
(b)	$v_f = v_i + at = 0 + 2.4ms^{-2} \times 4.0s$ $v_f = 9.6ms^{-1}$ OR $v_f{}^2 = v_i{}^2 + 2ad = 0 + 2 \times 2.4ms^{-2} \times 4.0s$ $v_f{}^2 = 92.16m^2s^{-2} \therefore v_f = 9.6ms^{-1}$	[2] Correct substitution and calculation Accept 4.8 ms^{-1} (carry error)		
(c)	Time remaining = 12.8s – 4.0s = 8.8s. Distance remaining = 100 – 19.2m = 80.8m $v = \frac{d}{t} = \frac{80.8m}{8.8s} = 9.18ms^{-1} = (9.2ms^{-1})$		[2] Correct substitution, incorrect time. (v=6.31 ms^{-1}) [NA if incorrect d]	[2] Correct substitution, inference and calculation.
(d)	Calc a first. $a = \frac{v_f - v_i}{t} = \frac{0 - 8.8ms^{-1}}{6.0s} = -1.466$ then calc d. $d = v_i t + \frac{1}{2} a t^2 = 8.8 \times 6.0 + \frac{1}{2}(-1.466) \times 6.0^2$ $d = 26.4m$	*[2] Consequential correct d if used incorrect a.*	[2] Correct substitution, rearrangement and calculation.	

Q1 Sufficiency:

A= 2A

M =1A + 2M

E = 2A + 1M +1E

Question	Evidence	Achievement	Merit	Excellence
TWO (a)	Ben's Acceleration = Gradient of vel vs t $a = \frac{\Delta v}{\Delta t} = \frac{10 - 0 ms^{-1}}{2.5 - 0 s} = 4.0 ms^{-2}$	[2] Correct substitution and calculation.		
(b)	Distance = area under graph = triangle $d = \frac{1}{2} \times 10 ms^{-1} \times 2.5 s = 12.5 m$	[2] Correct substitution and calculation.		
(c)	Barbara moved at $8.0 ms^{-1}$ for 2.5s = 20m. Ben moved 12.5m to be in the same place at t=2.5s. So Ben started 7.5m (20–12.5m) in front of Barbara, at t=0.0s		[2] Correct reasoning and calculation.	
(d)	$v_{avg} = \frac{d}{t}$ and distance = total area $d = 8.0 ms^{-1} \times 2.5 s + \frac{1}{2} 8.0 ms^{-1} \times (5.5 s - 2.5 s)$ $d = 20 m + 12 m = 32 m$ so $v_{avg} = \frac{32 m}{5.5 s} = 5.818 ms^{-1} = (5.8 ms^{-1})$		[2] Correct reasoning and calculation.	
(e)			[2] *$a_i = 4.0 ms^{-2}$ (allow consequential from 4(a))* *and* *$a_f = +1.0 ms^{-2}$.* *Only one line either +4 or -1 for Merit*	[2] Correct graph

Q2 Sufficiency:

A= 2A

M =1A + 2M

E = 2A + 1M +1E

Question	Evidence	Achievement	Merit	Excellence
Three (a)	Horizontal component of the initial velocity = 43 cos 42^o = 31.955227 = 32 m s^{-1} to 2 sig. fig.	[2] Correct working		
(b)	Vertical component of the initial velocity = 43 sin 42^o = 28.772616 = 29 m s^{-1} to 2 sig. fig.	[2] Correct working		
(c)	• Speed v = 32 m s^{-1} • The horizontal component of the golf ball remains constant. • This is because there is no unbalanced force acting on the golf ball in the horizontal direction (ignoring air resistance).	[1] 32 m s^{-1}	[1] Correct answer	
(d)	• Size = 9.8 m s^{-2} • Direction is vertically downwards.	[1] Size correct [1] Direction correct		
(e)	a = -9.8 m s^{-2}, v_i = 29 m s^{-1}, v_f = 0, d = ? $v_f^2 = v_i^2 + 2ad \Rightarrow d = \frac{v_f^2 - v_i^2}{2a} = \frac{0^2 - 29^2}{2(-9.8)}$ $= 42.908163 = 43\,m$		[2] Correct answer	
(f)	$v_f = v_i + at$ $t = \frac{v_f - v_i}{a} = \frac{0-29}{-9.8} = 2.96\,s$ Total time = twice time to top of flight. $T_{total} = 2.96 \times 2 = 5.92\,s$		[2] Correct time to top of flight	[2] correct time
(g)	On its way up, the velocity keeps decreasing at a constant rate of 9.8 m s^{-2} until it reaches zero. Once its velocity is zero it goes no higher, but starts falling down again with increasing velocity at the rate of 9.8 m s^{-2} until it hits the ground. The acceleration is constant throughout its motion and acts in a downward direction at 9.8 m s^{-2}. Speed at start is equal to speed at stop, assuming that these positions are the same vertical height.	[1] Describes decreasing velocity going up OR Describes increasing velocity on its way down OR Describes constant acceleration downwards.	[1] Describes constant acceleration downward OR Speed at start equal to speed at stop assuming the vertical height is the same. AND Either decreasing velocity on its way up OR Increasing velocity on its way down.	[1] Describes constant acceleration downward AND Decreasing velocity on its way up AND Increasing velocity on its way down AND Speed at start equal to speed at stop assuming the vertical height is the same.

Q3 Sufficiency:
A= 3A
M =2A + 2M
E = 2A + 2M +1E

Over all sufficiency:

2 questions at a grade to get that grade. I.e. 2 questions at M to get M.