Date: ____ / ____ / ____

Mark: 52 / 52

**PHYSICS YEAR 12 – MOTION TOPIC TEST 1**

Name: Solutions

Weight: 5%

Materials: *Pens/Pencils, Eraser, Ruler, Calculator, Formula Sheet.*

Time: 60 Minutes.

*Give all numerical answers to 3 significant figures (estimation questions to 2 significant figures), unless instructed otherwise in the question.*

1. A 70 kg cyclist (inc. bicycle) rides their bicycle North along a flat, level stretch of road at a constant velocity of 4.50 m $s^{-1}$, doing work against a 60.0 N friction force.

   a. What is the net force acting upon the cyclist? Justify your response:

   (2 Marks)

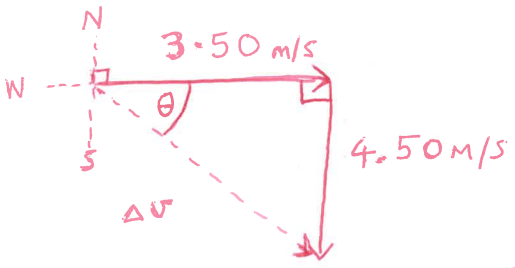
   $\Sigma F_{NET} = 0$ N ✓

   Cyclist is moving with constant velocity, ∴ all forces are balanced (Newton's 1st/2nd Law) ✓

   b. The cyclist turns to the East with a new constant velocity of 3.50 m $s^{-1}$. Find the change in velocity:

   (4 Marks)

   $\Delta v = v_f - v_i$




   ✓

   $\theta = \tan^{-1}\left(\frac{4.50}{3.50}\right)$

   $= 52.13°$ ✓

   Bearing $= 90° + 52.13°$

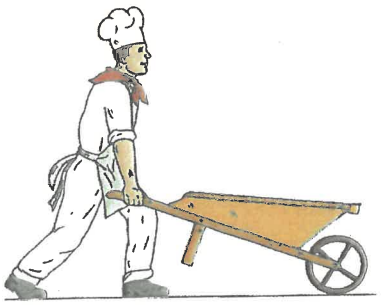
   $= 142.13°$T

   $|\Delta v| = \sqrt{(3.50)^2 + (4.50)^2}$

   $= 5.70$ m/s ✓

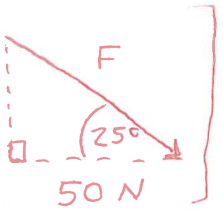
   ∴ $\Delta v = 5.70$ m/s on bearing 142°T ✓

2. A 20.0 kg wheelbarrow is being pushed at a constant velocity (by a chef… for reasons) such that the angle that the handle makes with the ground is 25°. A horizontal friction force of 50.0 N opposes the motion of the wheelbarrow.



a. Find the force applied by the chef on the wheelbarrow.

(2 Marks)




$\cos 25° = \frac{50}{F}$

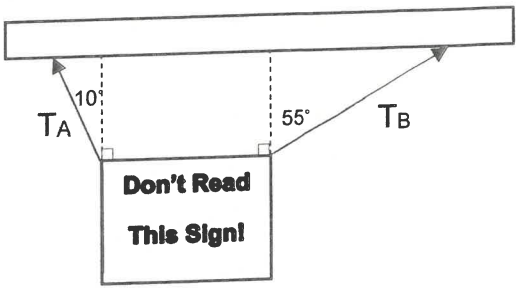
$\therefore F = \frac{50}{\cos 25°} = 55.2\ N$ towards axle

b. Find the force applied by the wheelbarrow on the chef.

(1 Mark)

55.2 N away from axle.

3. A sign has been suspended from the ceiling by two wires, each able to sustain a maximum force of 200 N. The sign has a mass of 5.00 kg. Calculate the tension force present in each wire and determine whether or not either wire shall fail (break).

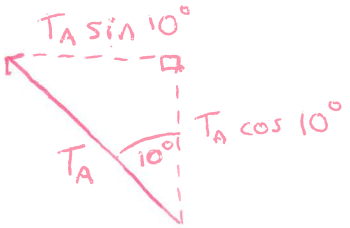



(5 Marks)

Method 1

$\Sigma F_{up} = \Sigma F_{down}$

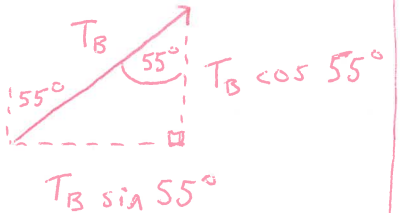
$T_A \cos 10° + T_B \cos 55° = 5 \times 9.8 = 49$ ①




$\Sigma F_L = \Sigma F_R$

$T_A \sin 10° = T_B \sin 55°$ ② (sub into ①)

$\therefore \frac{T_B \sin 55°}{\sin 10°} \cdot \cos 10° + T_B \cos 55° = 49$

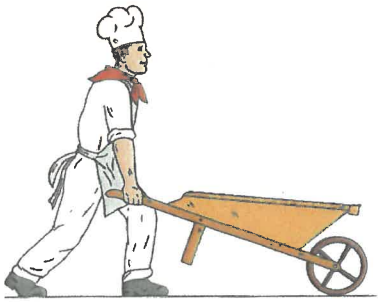



$\therefore T_B = 9.39\ N$ (sub into ②)

$T_A = 44.3\ N$

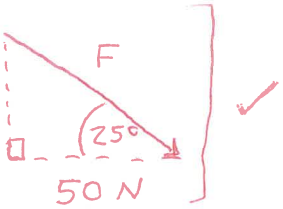
∴ Neither wire shall fail. ($T < 200N$)

2. A 20.0 kg wheelbarrow is being pushed at a constant velocity (by a chef… for reasons) such that the angle that the handle makes with the ground is 25°. A horizontal friction force of 50.0 N opposes the motion of the wheelbarrow.



a. Find the force applied by the chef on the wheelbarrow.

(2 Marks)

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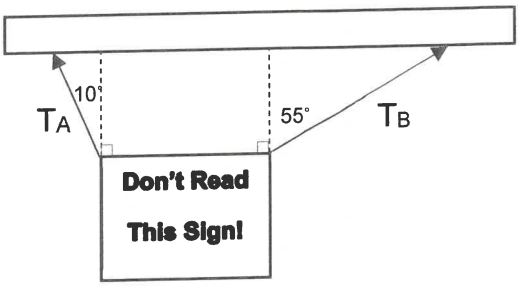
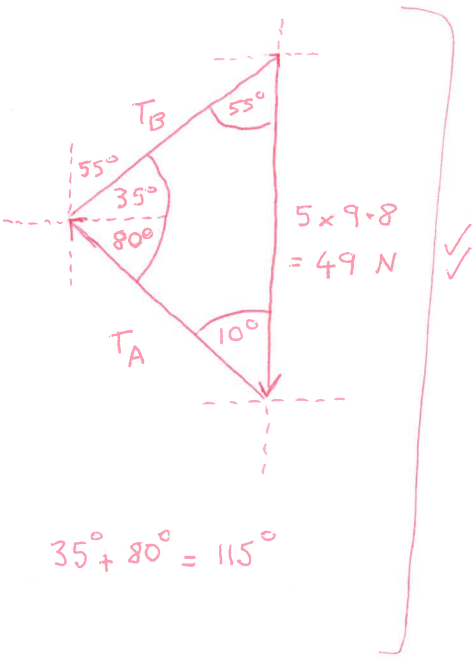



(5 Marks)

Method 2




$\frac{\sin 115°}{49} = \frac{\sin 10°}{T_B} = \frac{\sin 55°}{T_A}$

$\therefore T_A = 44.3\ N$

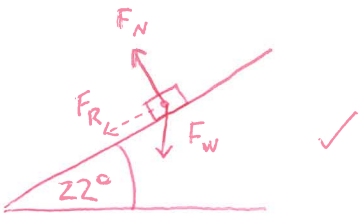
$T_B = 9.39\ N$

$\therefore$ Neither wire shall fail $(T < 200N)$

4. Removalists need to load a 136 kg piano into a truck by placing it on a wheeled trolley and roll it up a ramp inclined at an angle of 22°. Ignore friction.

a. The ramp will bend significantly if the normal reaction exerted by the ramp exceeds 1250 N. Using calculations determine whether the ramp will bend significantly (ignore the weight of the removalists).

(4 Marks)



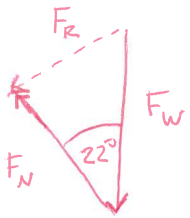

✓

$F_W = 136 \times 9.8 = 1332.8\,N$

$\cos 22° = \dfrac{F_N}{1332.8}$

$\therefore F_N = 1332.8 \cos 22°$

$= 1235.75\,N$ or $1.24 \times 10^3\,N$ ✓




✓

$\therefore$ Ramp will not bend significantly as $F_N < 1250\,N$ ✓

b. Calculate the minimum force up the ramp that must be exerted by the removalists to load the piano into the truck.

(2 Marks)

✱ To get piano up ramp at constant velocity, the removalists need only overcome $F_R$ by exerting an equal but opposite force.

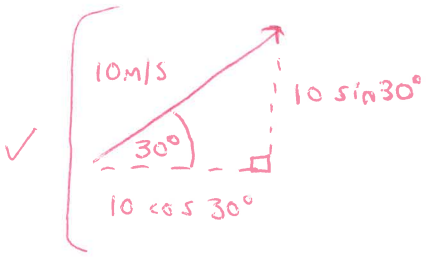
$\sin 22° = \dfrac{F_R}{1332.8}$ ✓

$\therefore F_R = 1332.8 \sin 22°$

$= 499.28\,N$ or $4.99 \times 10^2\,N$ (will accept 500N) ✓

5. A projectile is launched from a flat piece of land with a speed of 10.0 m $s^{-1}$.

   a. Find the range if the projectile is launched at 30° to the horizontal:
   (3 Marks)




Time of Flight (TOF)

TOF = 2 × Time to Max Height (TTM)

$TTM = \frac{v_v - u_v}{a_v} = \frac{0 - 10\sin 30^\circ}{-9.8} = 0.51\,s$

$\therefore TOF = 1.02\,s$ ✓

$\therefore Range = u_H t = (10\cos 30^\circ)(1.02) = \boxed{8.84\,m}$ ✓

   b. What angle, other than 30°, would achieve the same range for the projectile (assuming the same initial speed)? Justify your response:
   (2 Marks)

60° ✓

Angles $(0 \leq \theta \leq 90^\circ)$ equidistant from 45° will achieve the same range. ✓

⊛ student may justify with a calculation if they wish.

6. Consider the motion-capture image below, taken from the 2018 PyeongChang Winter Olympics ski-jumping event in South Korea. Consider the first position of the ski-jumper to have been taken at time t = 0 seconds, and the angle of the jump to be approximately 70° to the horizontal. The maximum height achieved by the ski-jumper (above the first position) measures at 5.62 m.

a. Find the initial speed of the ski-jumper: (2 Marks)

$v_v = 0$ m/s
$u_v$ ?
$a_v = -9.8$ m/s$^2$
$s_v = 5.62$ m

$v_v^2 = u_v^2 + 2a_v s_v$

$\therefore u_v = \sqrt{v_v^2 - 2a_v s_v}$

$= \boxed{10.49 \text{ m/s}}$ ✓


$\sin 70° = \frac{10.49}{u}$

$\therefore u = \frac{10.49}{\sin 70°}$

$= \boxed{11.17 \text{ m/s}}$ ✓

b. Find the time to reach maximum height: (1 Mark)

$v_v = 0$ m/s
$u_v = 10.49$ m/s
$a_v = -9.8$ m/s$^2$
$t = ?$

$t = \frac{v - u}{a}$

$= \frac{-10.49}{-9.8}$

$= \boxed{1.07 \text{ s}}$ ✓

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

c. Find the frequency of the camera shutter: (2 Marks)

$f = \frac{\#\text{ snaps}}{\#\text{ seconds}} = \frac{4}{1.07} = \boxed{3.73 \text{ Hz}}$ ✓✓

Not counting image at time $t = 0$.

d. Find the total time over which the image was taken: (2 Marks)

$T = \frac{1}{f} = 0.268$ s ✓

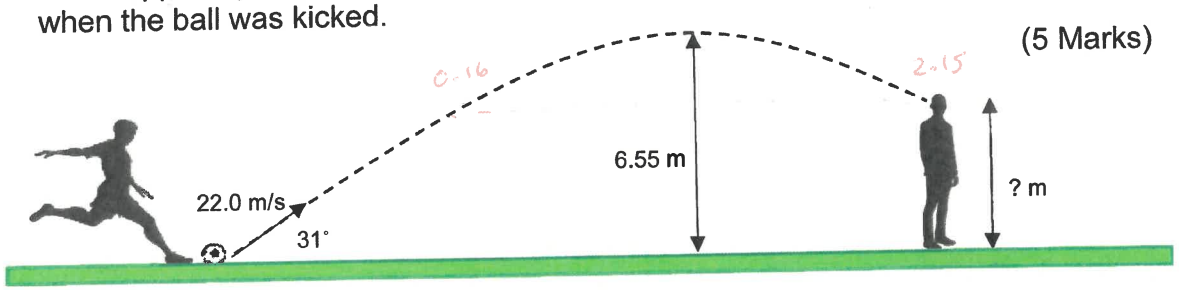
$\therefore t = 0.268 \times 11 = \boxed{2.95 \text{ s}}$ ✓

e. Find the range of the jump: (2 Marks)

$s_H = (11.17 \cos 70°)(2.95)$ ✓

$= \boxed{11.25 \text{ m}}$ ✓

7. A soccer player kicks a soccer ball with a speed of 22.0 m $s^{-1}$ at an angle to the horizontal of 31°. The ball achieves a maximum height of 6.55 m, before hitting an unsuspecting stationary opposing player in the head. By *estimating* the height of the opposing player, calculate how far away he was standing from the kicker when the ball was kicked. (5 Marks)




$h = s_v = 1.7\text{m}$ $(1.5 - 1.9\text{m})$ ✱ Accept estimates in this range. ✓

$s_v = u_v t + \frac{1}{2} a_v t^2$

$\therefore t = \dfrac{-u_v \pm \sqrt{u_v^2 + 2 a_v s_v}}{a_v}$

$= \dfrac{-(22 \sin 31°) \pm \sqrt{(22 \sin 31°)^2 + 2(-9.8)(1.7)}}{-9.8}$ ✓

$= 0.16\text{s}$ or $2.15\text{s}$ ✓

✱ Reject lower value as this is before max. height is achieved.

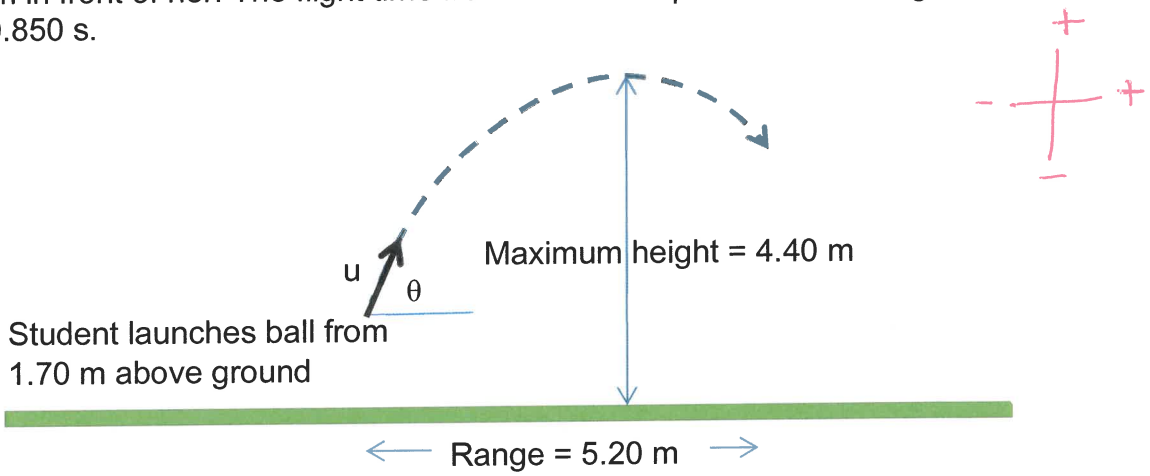
$\therefore$ Range $= s_H = (22 \cos 31°)(2.15) = 40.565\text{m}$ ✓

$= 40.6\text{m}$

$= \boxed{41\text{m}}$ (2 s.f.) ✓

✱ Final Mark is for giving answer in 2 sig. figs., as this is an estimation question.

8. A student tries to throw her ball over a tall fence. The ball is launched at an angle θ to the horizontal. The ball reaches its maximum height of 4.40 m above the ground, continues and then strikes the top of the fence at a horizontal distance of 5.20 m in front of her. The flight time from the launch position to striking the fence was 0.850 s.




a. Calculate the initial velocity of the ball. Note that this is a vector quantity.

(5 Marks)

Vertical

$V_V = 0\,m/s$ (at Max Height)

$u_V = ?$

$a_V = -9.8\,m/s^2$

$s_V = 4.4 - 1.7 = 2.7\,m$

$\therefore V_V^2 = u_V^2 + 2a_V s_V$

$\therefore 0^2 = u_V^2 + 2(-9.8)(2.7)$

$\therefore u_V = 7.27\,m/s$ ✓

Horizontal

$s_H = 5.20\,m$

$a_H = 0\,m/s^2$

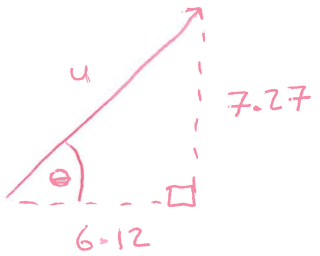
$u_H = ?$

$t = 0.85\,s$

$\therefore s_H = u_H t + \frac{1}{2}a_H t^2$ ($a_H = 0$)

$\therefore u_H = \frac{s_H}{t} = \frac{5.20}{0.85}$

$u_H = 6.12\,m/s$ ✓




✓

$u = \sqrt{6.12^2 + 7.27^2}$

$= 9.51\,m/s$ ✓

$\theta = \tan^{-1}\left(\frac{7.27}{6.12}\right) = 49.9°$ ✓

$\therefore$ $u = 9.51\,m/s$ @ $49.9°$ to the horizontal.

b. Calculate the height of the fence. If you could **not solve** for the initial velocity **u** then use a value of 9.50 m $s^{-1}$ at 55.0° above the horizontal.

(4 Marks)

$s_v = ?$

$u_v = 7.27 m/s$

$a_v = -9.8 m/s^2$

$t = 0.85 s$ ✓

$s_v = u_v t + \frac{1}{2} a_v t^2$

$= 7.27(0.85) + \frac{1}{2}(-9.8)(0.85)^2$ ✓

$= 2.64 m$ above launch height. ✓

Launch Height = 1.70m

∴ Height of fence = 2.64 + 1.70 ✓

= **4.34m**

⊛ If they used 9.50m/s & 55°, they should get a height of 4.77m for the fence.

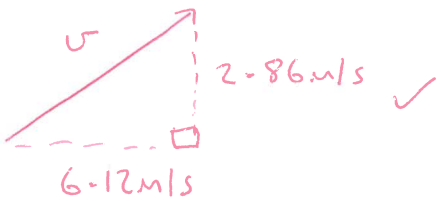
c. The kinetic energy of the ball after 0.450 seconds of flight was 19.14 J. Calculate the mass of the ball.

(4 Marks)

$v_v = u_v + a_v t$

$= 7.27 + (-9.8)(0.45)$

$= 2.86 m/s$ ✓




✓

$v = \sqrt{6.12^2 + 2.86^2} = 6.76 m/s$ ✓

$19.14 = \frac{1}{2} m (6.76)^2$

$\therefore m = \frac{2 \times 19.14}{(6.76)^2} = 0.84 kg$ ✓

⊛ If they used values given as alternates in part b...

$v = 6.41 m/s$

$m = 0.93 kg$

END OF TEST