Physics 1A QUIZ 1 . Closed Book. Write in blue or black ballpoint only.

Assume earth's gravity $g = 10\ m/s^2$.
Constant - acceleration equations:
$v = v_0 + at \quad x = x_0 + v_0 t + \frac{1}{2} at^2 \quad v^2 = v_0^2 + 2ax$

1. After a foiled bank heist, the suspects carjack an ice-cream truck and take off from the bank at a uniform speed of 20 m/s. The police arrive at the bank and begin the chase 4 minutes (240s) later, traveling at a uniform speed of 35 m/s.

a. How far do the suspects get from the bank before the cops catch up to them?
b. How long (after leaving the bank) does it take the cops to catch them?
c. On the same axes, sketch a graph of distance vs. time for the cops and the suspects, showing the point at which the distances covered are the same.
(30 points)

2. Every year at UCSD, graduating Physics students celebrate by dropping watermelons from the roof of Urey Hall onto the ground below. Neglect air friction for these dense, aerodynamic projectiles, **and use g=10 m/s^2.**

a. If each melon falls for 1.5s, show that the building's height is about 11.3m (give 2 decimal places).

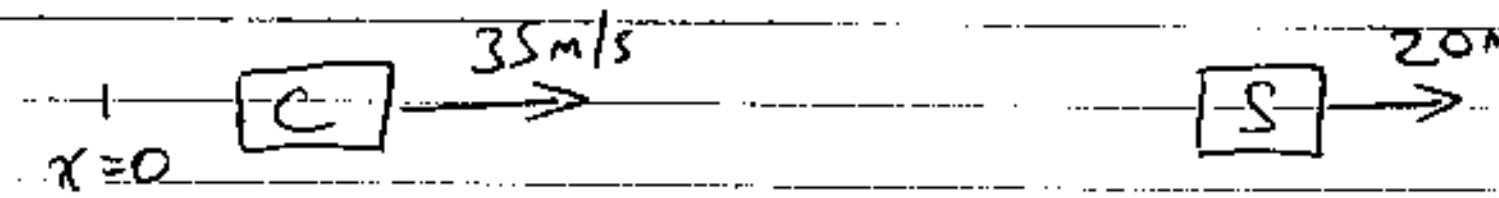
One of the watermelons is launched horizontally off the roof at 12 m/s.
b. How far from the building's base does the melon hit the ground?
c. What is (i) its total speed through the air (in m/s) just before impact, and (ii) its angle of impact with the ground, in degrees? (Hint: first calculate the vertical component of its velocity). **(40 points)**

3. A plane can fly through the air at 300 km/h. The wind is blowing from North to South at 50 km/h. The pilot desires to follow a track due east over the ground and so must point the plane's nose slightly into the wind to achieve this.

(a) Draw a vector diagram showing the velocity of the plane, the wind, and the resulting easterly track across the ground.
(b) At what heading (degrees E of N) must the pilot point the plane to achieve this ground track?
(c) what is the resulting speed of the plane over the ground?
(30 points)

Physics 1A Quiz 1 Solutions

1



Let bank be at $x = 0$. First need equations of uniform motion (accel $a = 0$) for suspects and cops:

$$x = x_0 + vt$$

e.g. Start clock ($t = 0$) when suspects leave:

Suspects, $v = 20\,m/s$, $x_0 = 0 \Rightarrow x = 20t$ (1)

Cops, $v = 35\,m/s$ $x = 0$ when $t = 240s$

$\therefore x = 35(t - 240)$

$= -8400m + 35t$ (2)

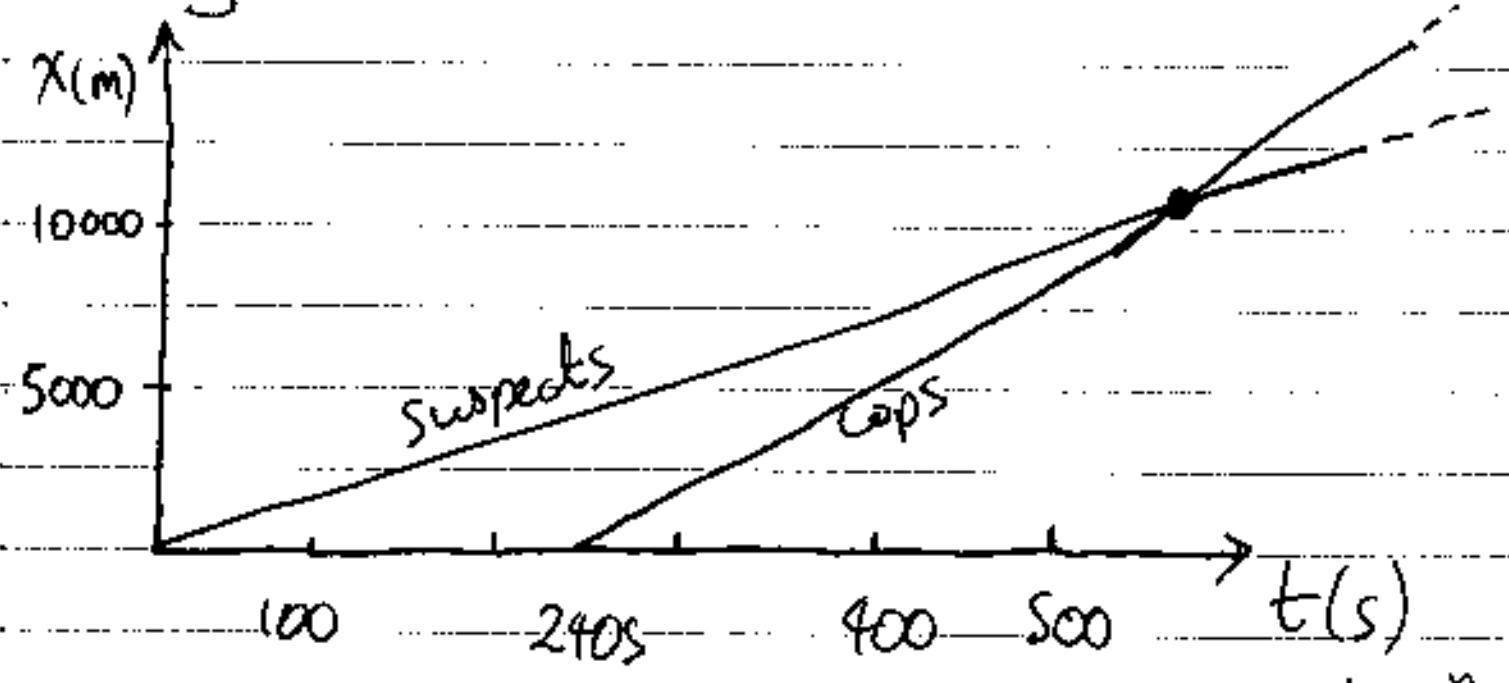
a) When the cops catch up, distance x given by (1) = (2)

i.e. $20t = -8400 + 35t \Rightarrow t = \frac{-8400}{20-35} = 560s$

$\therefore$ distance $x = 20t = 11200\,m$ or $11.2km$

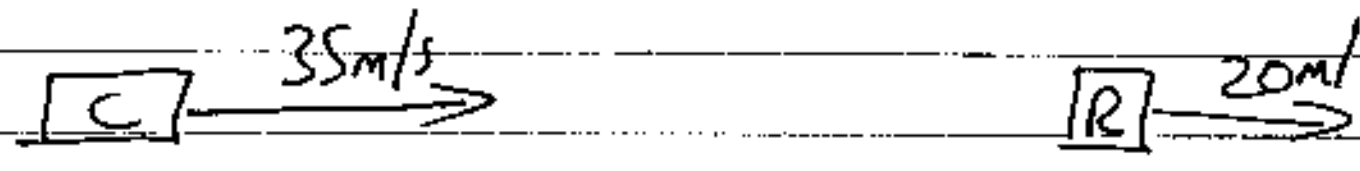
b) Time in transit for cops is $t - 240s = 320s$

c) Taking t as above:



1. Alternate Solution:

Instead, measure t from instant cops begin chase



Then suspects have a 240s head-start

i.e. $x = x_0 + V_s t$ with $x_0 = 240s \times 20m/s = 4800m$

∴ Suspects: $x = 4800 + 20t$ (1)

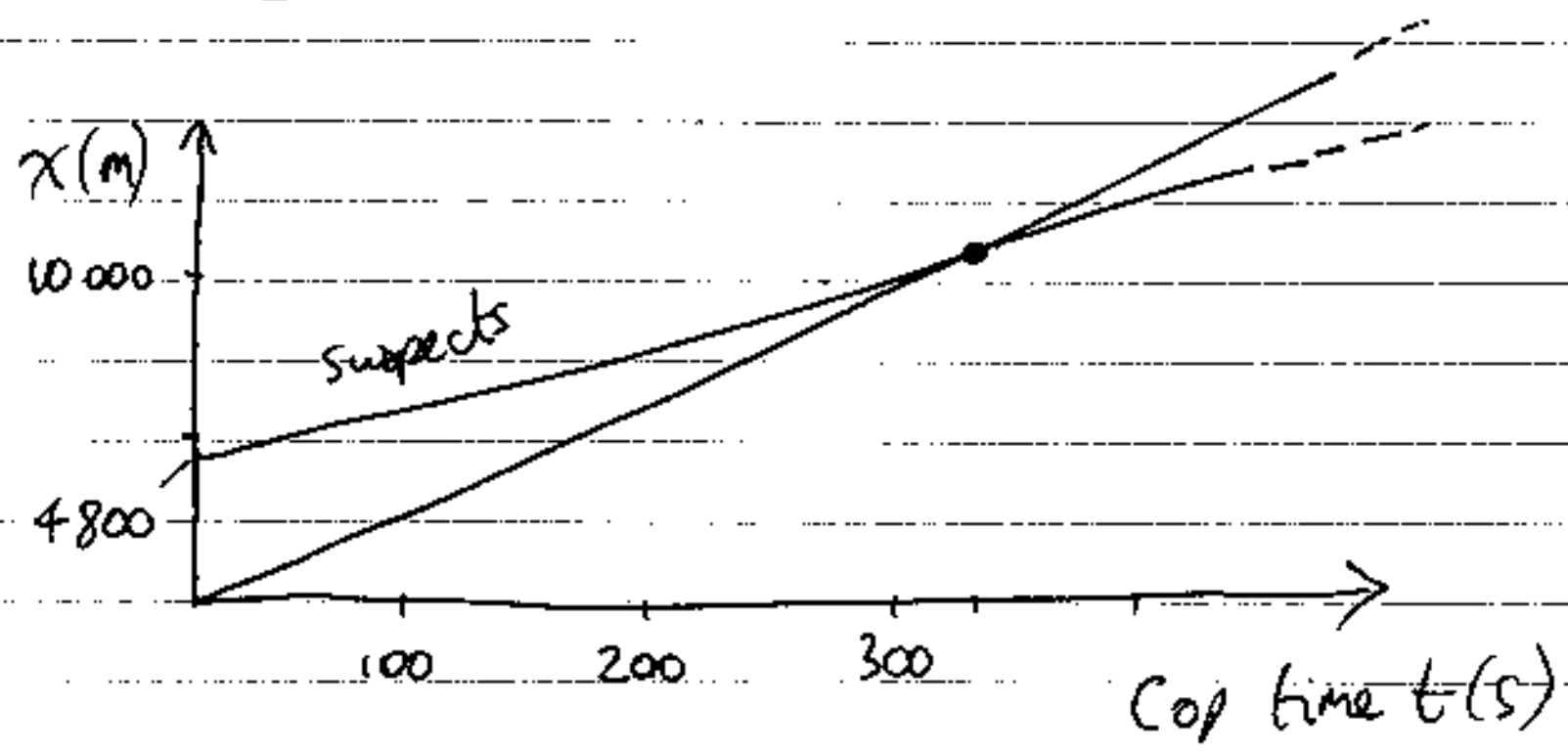
Cops $x = 35t$ (2)

a) When (1) = (2), $t = \frac{4800}{35-20} = 320s$ as before

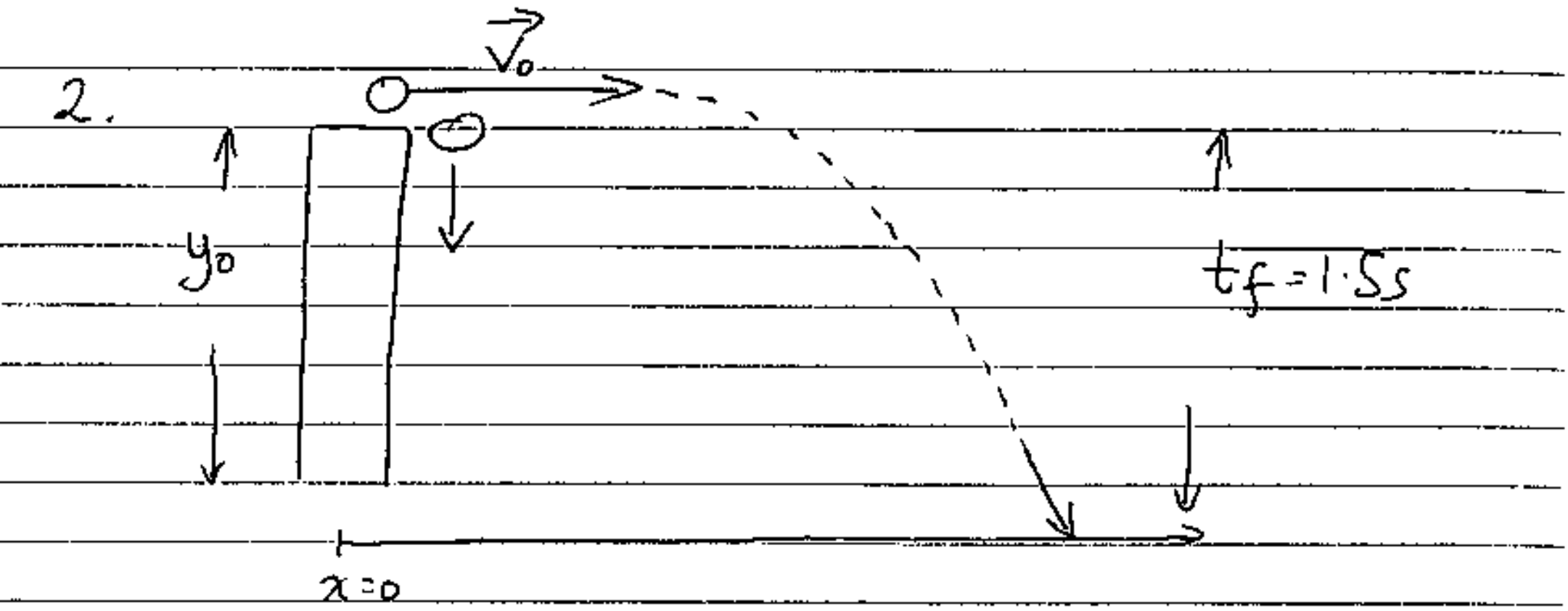
Distance $x = 35t = 11.2km$ as before

b) Already found $t = 320s$ as measured by cops

c)



2.



a) Taking y as the height above ground

we have $y = y_0 - \frac{1}{2} g t^2$ since $V_y = \frac{dy}{dt} = 0$ at $t = 0$

$\therefore$ Melon hits ground when $y = 0$, i.e. $y_0 = \frac{1}{2} g t_f^2$

where time of flight $t_f = 1.5s$, $g = 10 m/s^2$

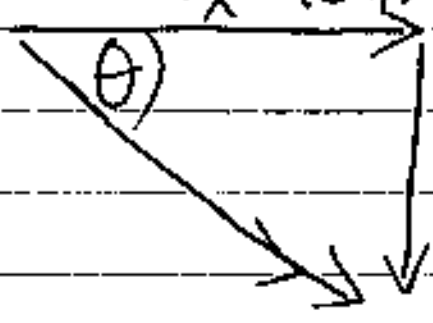
$\Rightarrow y_0 = \frac{1}{2} \times 10 \times (1.5)^2 = 11.25 m$

b) Taking x as distance from building

$x = V_x t$ so after time t_f with $V_x = 12 m/s$

$x = 12 \times 1.5 = 18 m$

c)



V_x = constant = 12 m/s

$V_y = V_{y0} - gt = -gt$

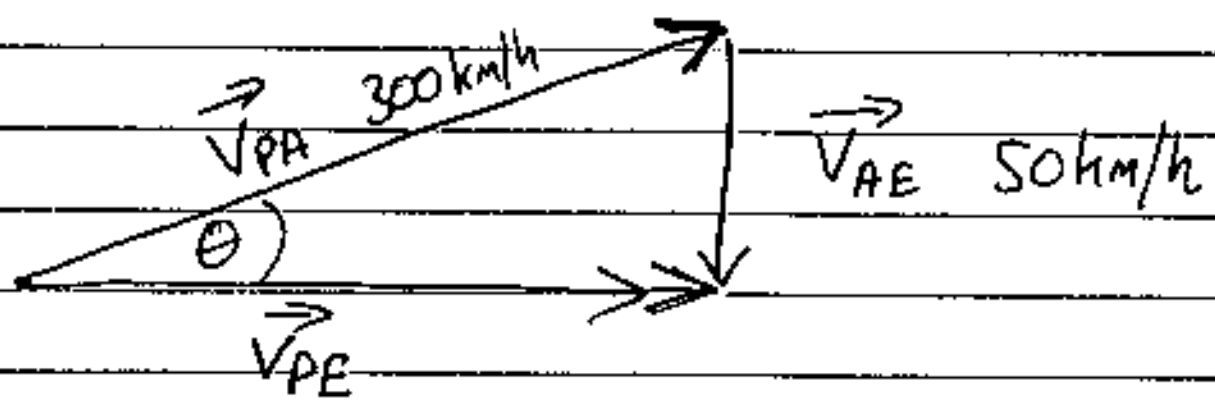
At impact, $V_y = -g t_f = -10 \times 1.5 = 15 m/s$

$\therefore$ total speed $V = \sqrt{V_x^2 + V_y^2} = \sqrt{12^2 + 15^2} = 19.2 m/s$

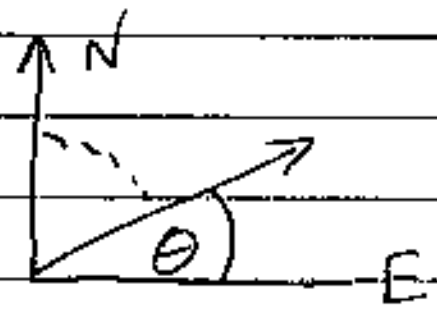
angle of impact $= \tan^{-1}\left(\frac{V_y}{V_x}\right) = \tan^{-1}\left(\frac{15}{12}\right) = 51.34^\circ$

3.

a) P = Plane A = Air E = Earth



b)



Heading = $90° - \theta$ (east of North)

From vector diagram, angle θ given by $\sin\theta = \frac{50}{300}$

$\therefore \underline{\theta = 9.6°}$ so heading = $90° - 9.6° = \underline{80.4°}$

c) Ground speed $|\vec{V}_{PE}| = \sqrt{300^2 - 50^2} = \underline{295.8 \text{ km/h}}$

(So we sacrificed some speed in order to fly cross-wind)