ME 599/AA 546/EE 546:
Biology-inspired robot control

Lecture 3
Sawyer B. Fuller

Goals:

- More detail on term project
- Example paper presentation and discussion lead: McLeod & Dienes, “Do fielders know where to catch the ball or only how to get there”

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recap

- last session, I gave an overview of dynamics and control

- introduced state-space formulation which is very useful for numerical simulation

- extended example of insect robot flight control

    - a fast inner loop controlled attitude, while a slower outer loop controlled set point for inner loop to control position

tentative presentation schedule

- anybody taking the class who's not on there?

upcoming project dates

- Guest lecture Friday: Sam Burden (EE): “Mechanical intelligence”

- Pset 1 due Friday in class
  * please turn it in to Sam Burden *

- <1 page proposals (1 per team/person) due on Canvas by class on Wednesday Oct 12

- Mid-term project presentations Oct 28-Nov 2

- Final project presentations Dec. 2-7

- Final papers due Fri Dec. 9 on Canvas

term project

- implement a new component to bio-inspired robot control system in simulation
- criteria for success:
  - novelty, e.g. new capability, new way of doing something
  - does something interesting (e.g. not just wiggle randomly)
  - suggestion: start with a simple system/idea and work upward
  - think of this as an advanced (2-4x normal) problem set with a more open-ended solution
  - good news: there are a large number of open problems!
  - HAVE FUN!

bio-inspired robotics

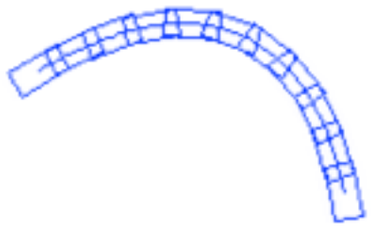
$$f = ma$$

$$\dot{\boldsymbol{x}} = \boldsymbol{f}(\boldsymbol{x}, \boldsymbol{u})$$

analysis

robotic implementation
(100x more work)

(physical hardware accepted as well, but get my permission)



simulation
(10x more work)

term project
suggested topics list

Friday

- problem set 1 due in class (posted on canvas)
- guest speaker: Prof. Sam Burden

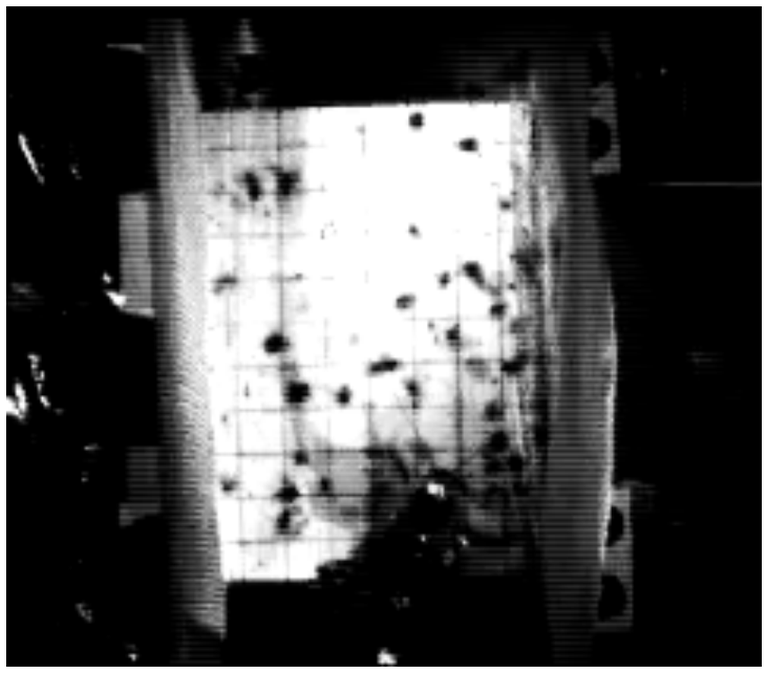
Wednesday

- project proposals <1 page due by class on canvas
    - indicate which project, what direction you will go, anticipated challenges
- paper 1 review due Tuesday

Preview of next paper

- Jindrich and Full, “Dynamic stabilization of rapid hexapedal locomotion”, J. Experimental Biology 2002.

- They mounted a *cannon* on the back of a cockroach and measured how it compensated



- results support hypothesis that cockroaches basically run in “open-loop”!

today

- example presentation & discussion

Do fielders know where to go to catch the ball or only how to get there

Peter McLeod & Zoltan Dienes

Journal of Experimental Psychology, 1996

Presented by Sawyer Fuller

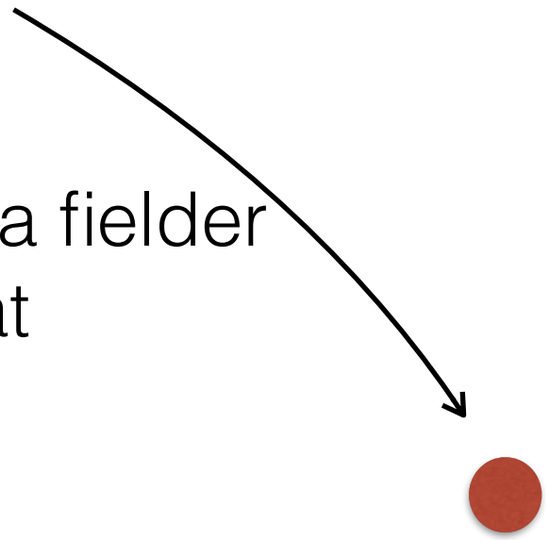
does this fielder know where ball will land?

previous work

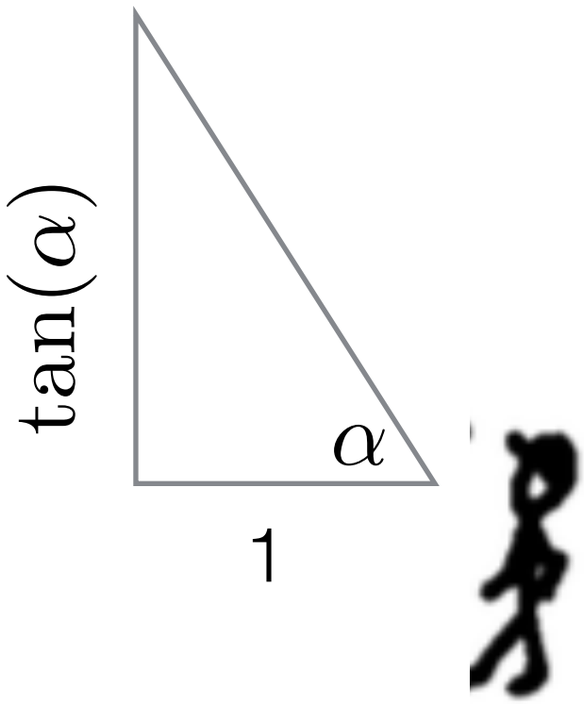
- Chapman (1968) observed that if a fielder runs at a constant speed such that

$$\frac{d}{dt}\tan(\alpha) = const$$

she will intercept a parabolic trajectory

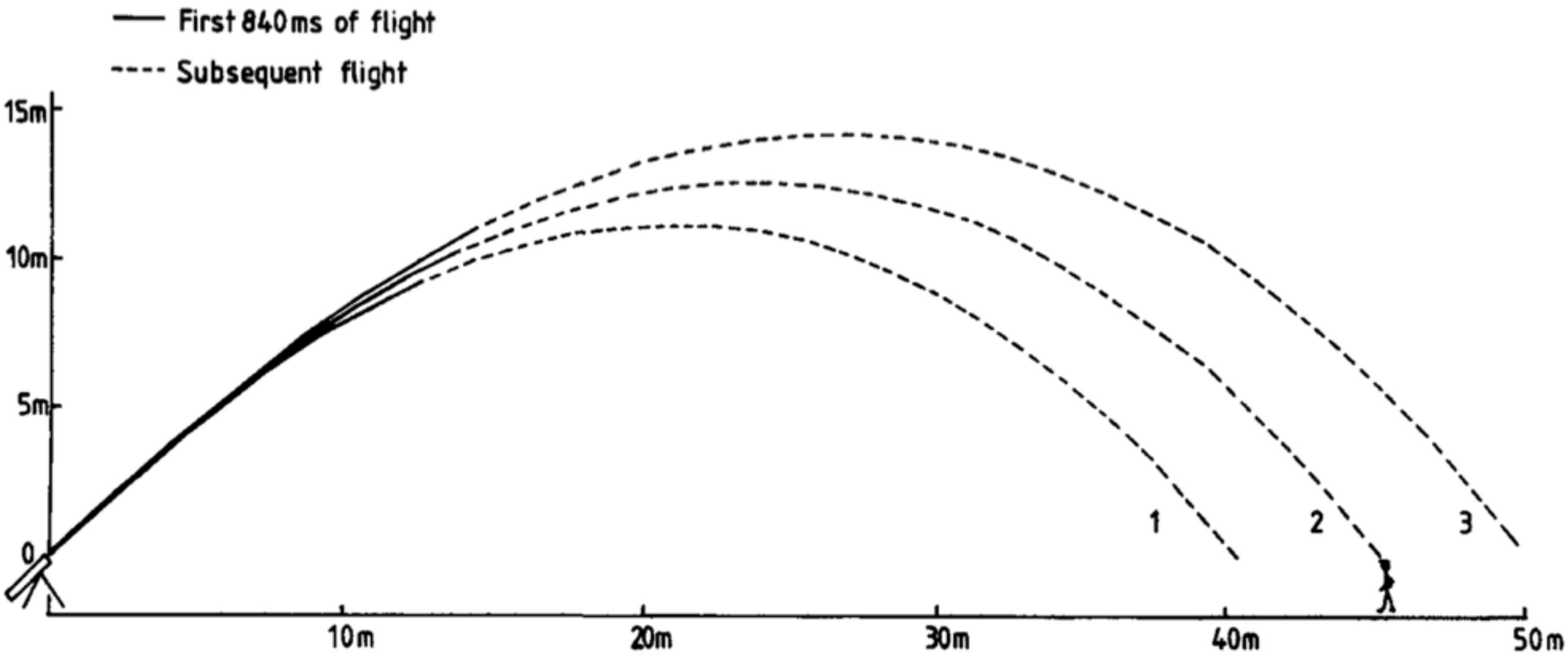


- problems:
  - because of air drag, path of ball is far from parabolic
  - does not specify how to choose the "constant running speed"



background

- Experimental setup: fielder catching fly balls
- focus on front-to-back motion, not side-to-side



Experimental setup

- camera tracks fielder

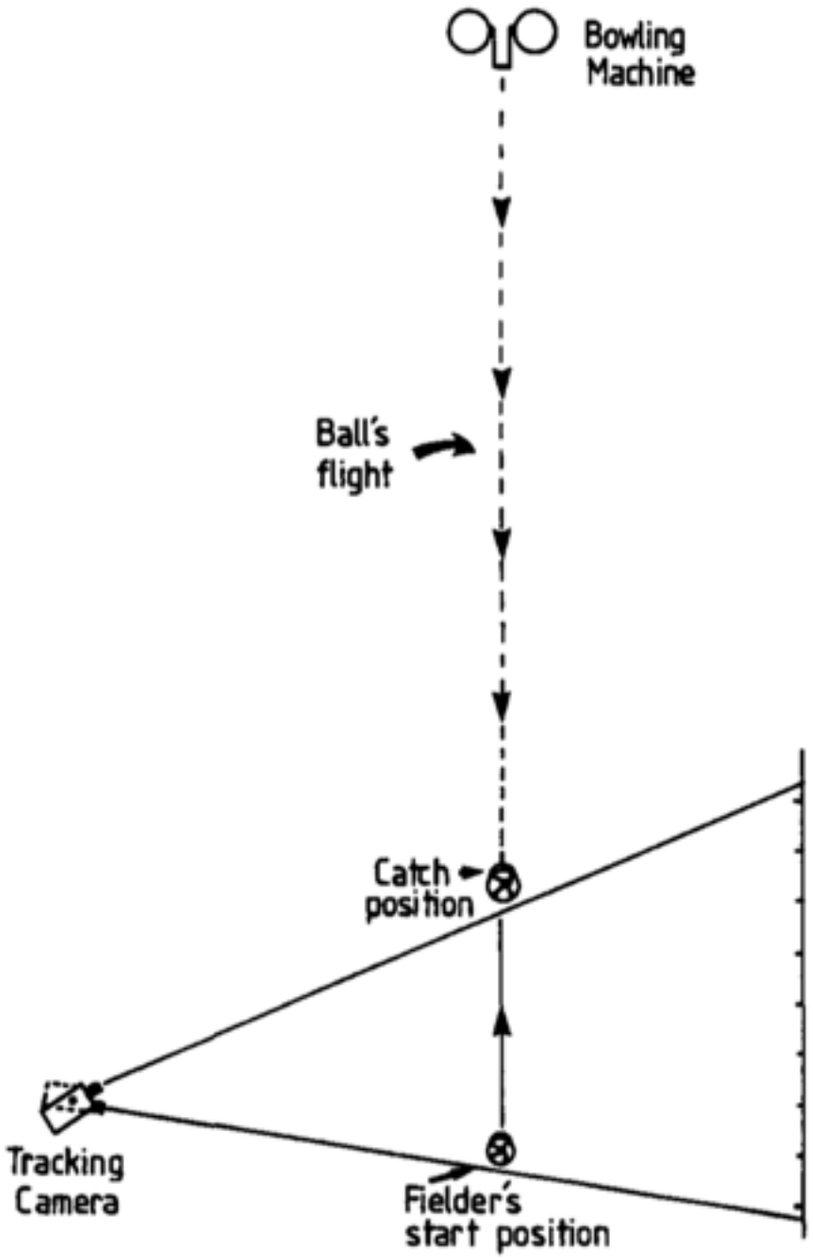


Figure 2. The experimental setup as viewed from above. A

experiment 1: 45deg at different speeds

- variable running speed, but dtan(alpha)/dt ~ const

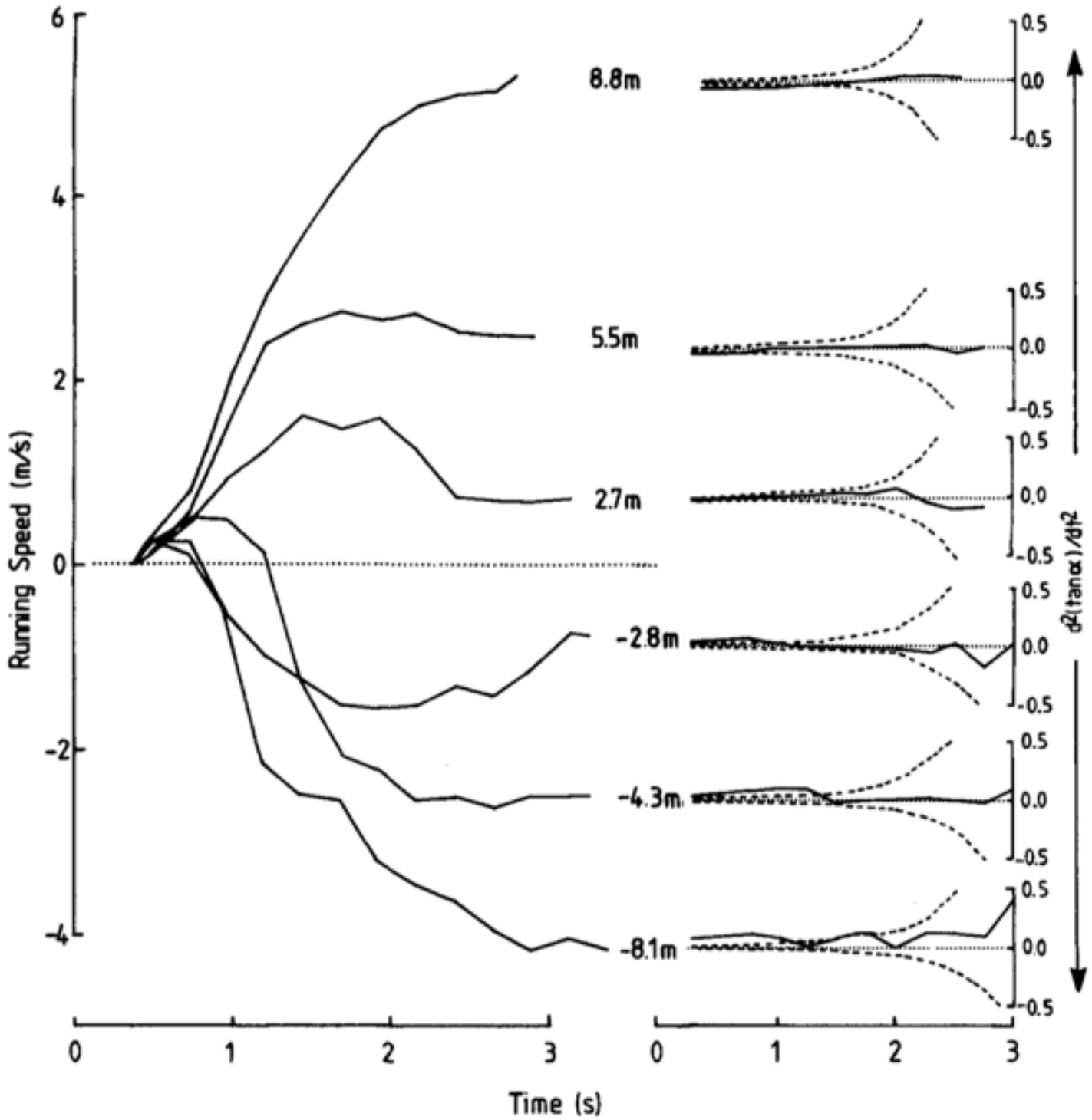
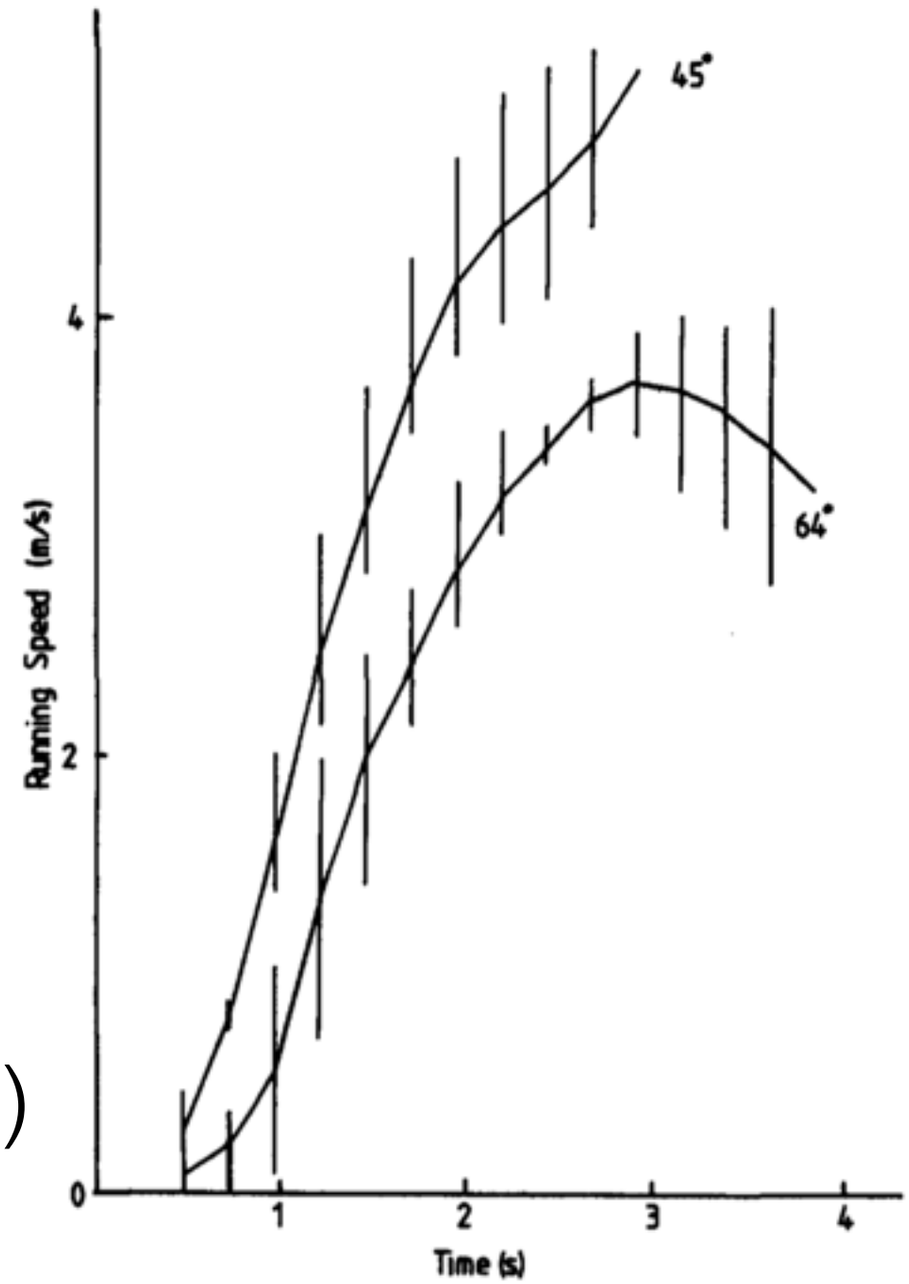


Figure 3. The left panel shows the fielder's running speed as

experiment 2: 45 and 64 deg



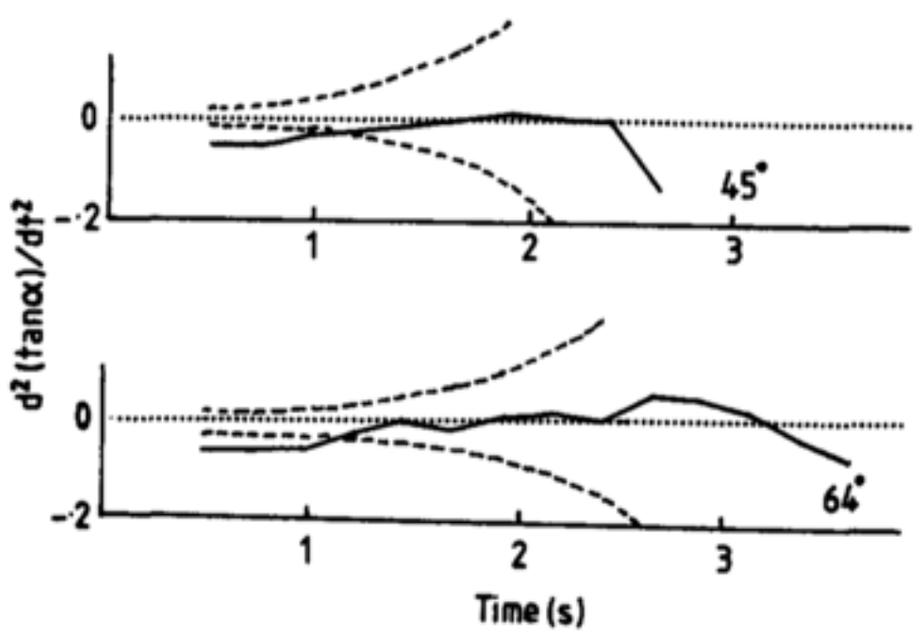


Figure 4. The fielder ran to catch balls landing 8–10 m in front

(figure 4)

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missing the ball

- running too slowly so that d2tan(alpha)/dt2 never goes to zero

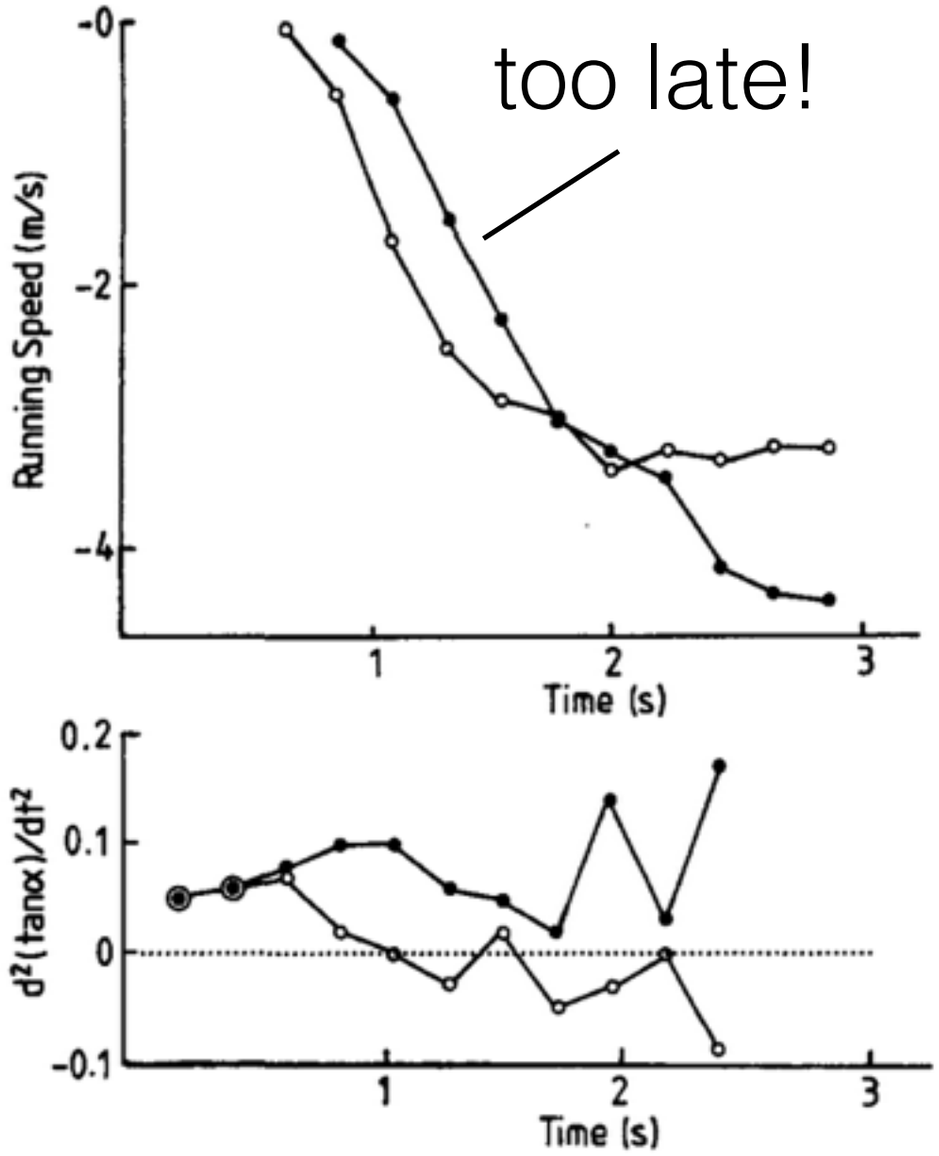

Figure 5. Velocity and $d^2(\tan \alpha)/dt^2$, as in Figure 3, for two

failure modes

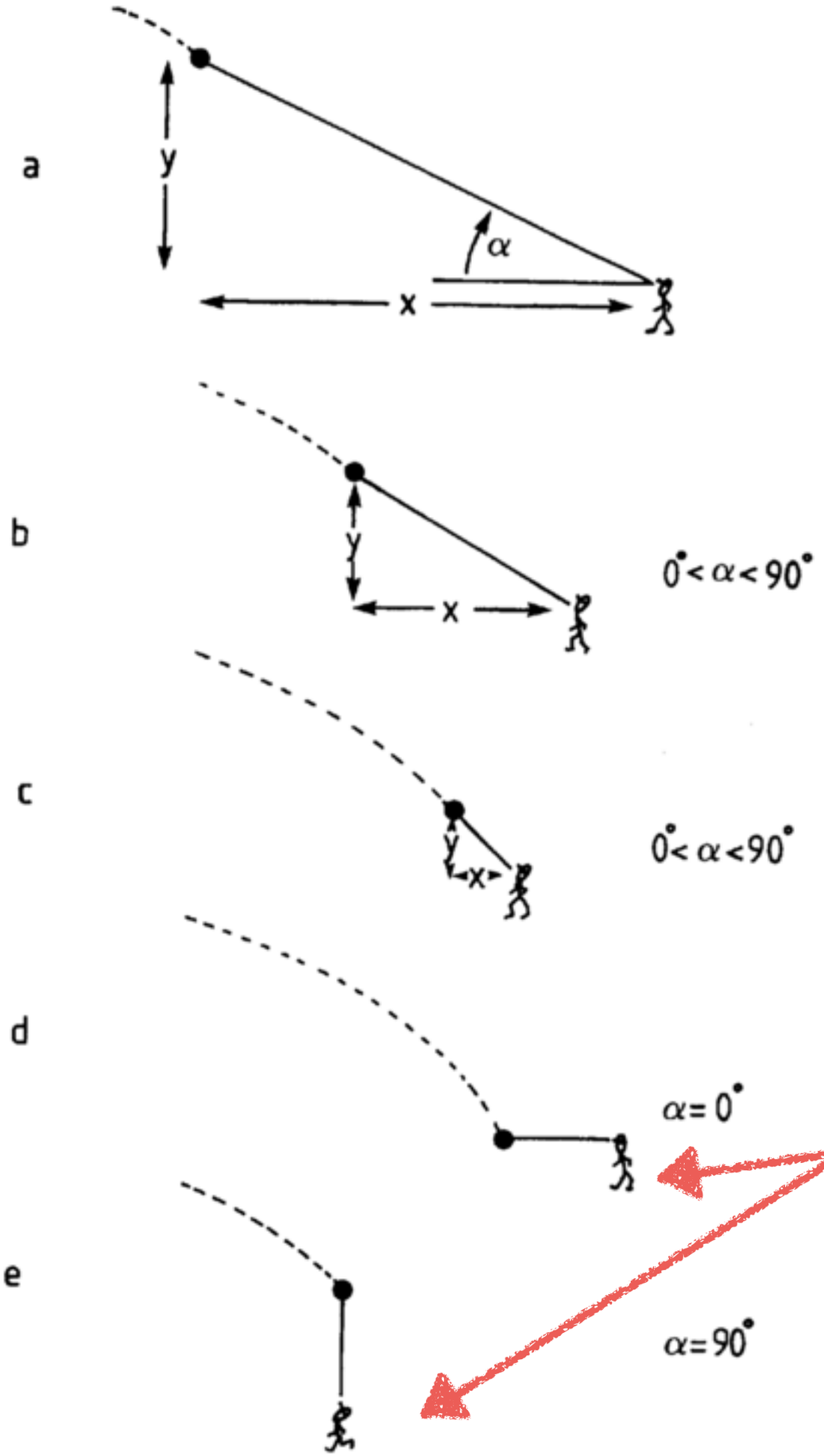

Figure 6. The conditions for intercepting or missing the ball. (a) α is the angle of elevation of gaze

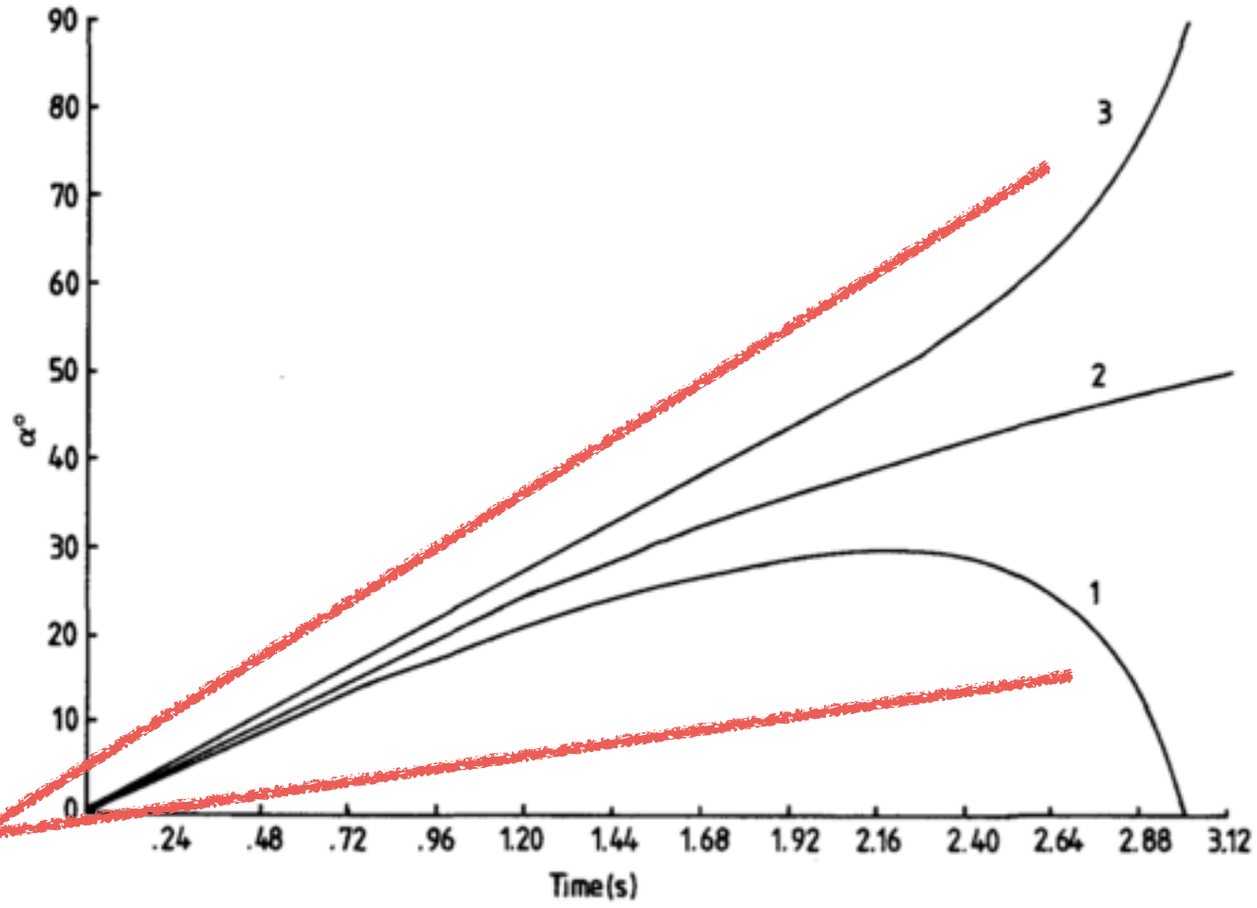

Figure 7. How the angle of elevation of gaze, α, varied with time as the stationary fielder in

alternative hypotheses

- rejected: keeping alpha constant

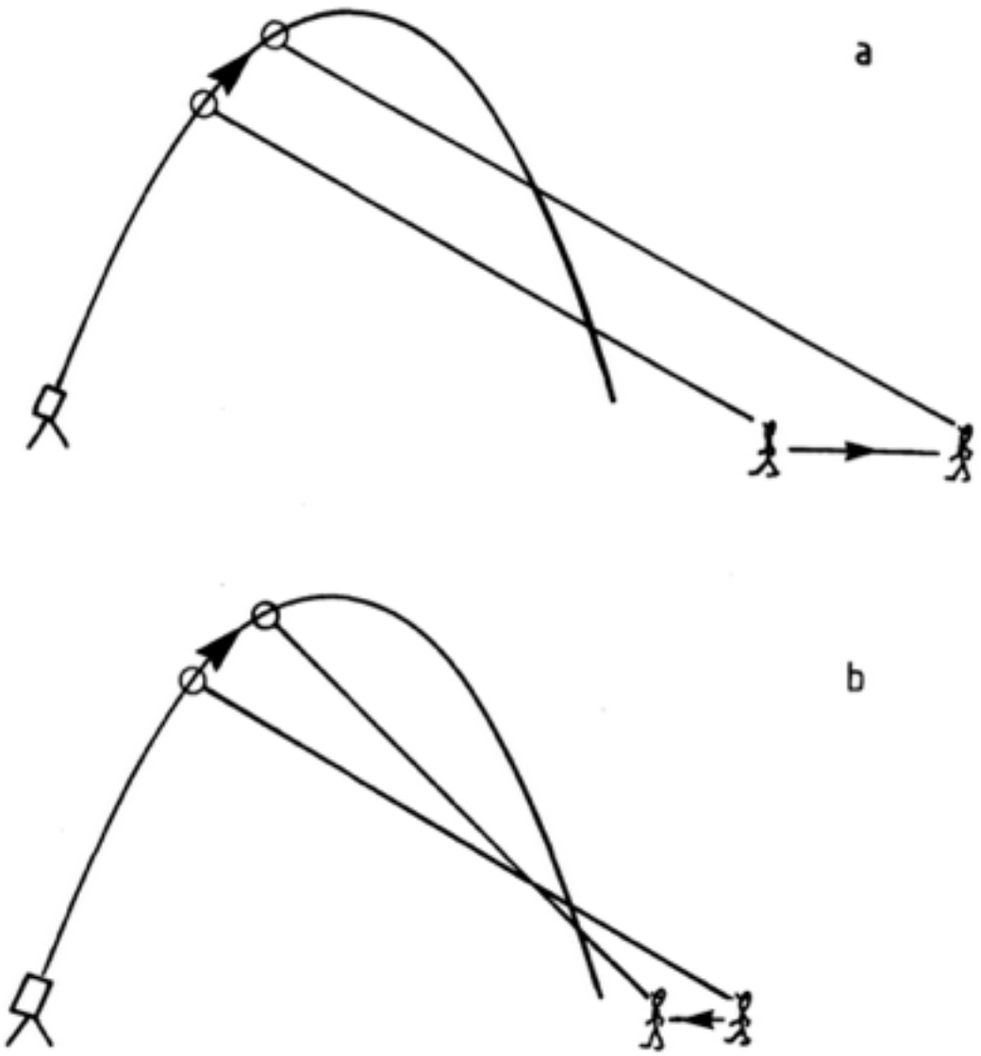

Figure 8. Two strategies for interception when the fielder should run forward. (a) Keeping the

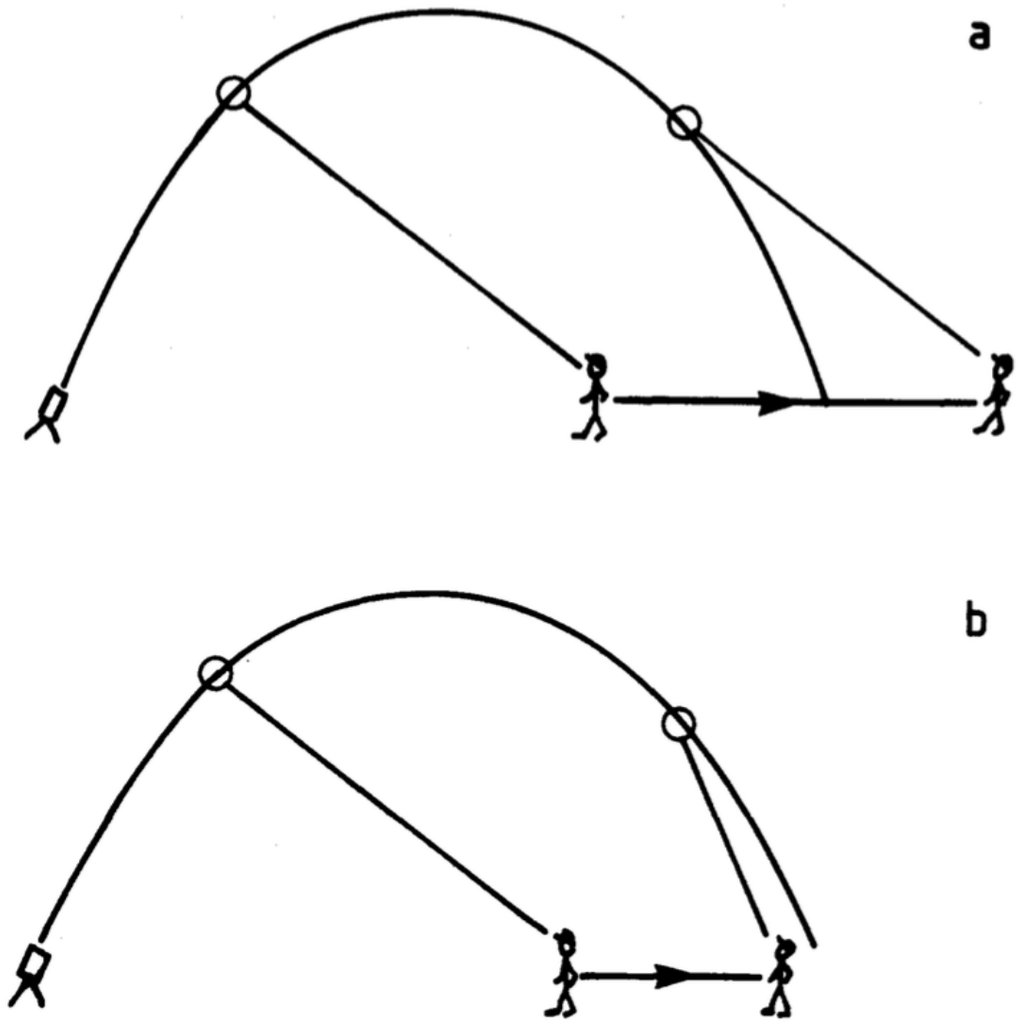

Figure 9. Two strategies for interception when the fielder is running backward. (a) Keeping the

alternative hypotheses

- rejected: d alpha/dt = constant (lines not straight)

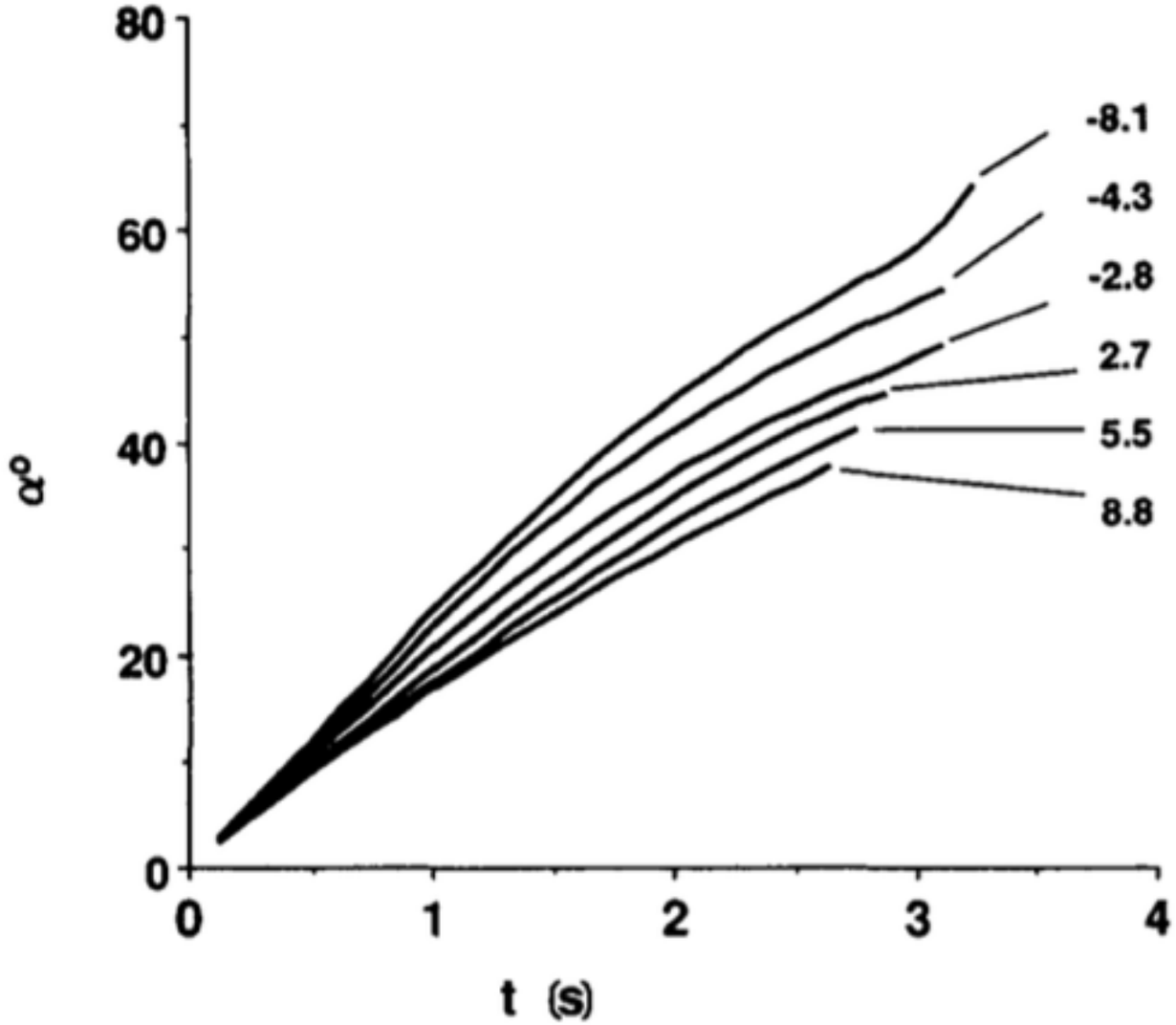

Figure 10. Angle of gaze as a function of time for the six

conclusions

- fielders are not running at constant speed to ball
- consistently, they are running at the moment they intercept it
- they didn't use spare time to run to where the ball would fall
    - this suggests they don't know where that will be