Instructors' Beliefs About Teaching Using Example Problem Solutions*

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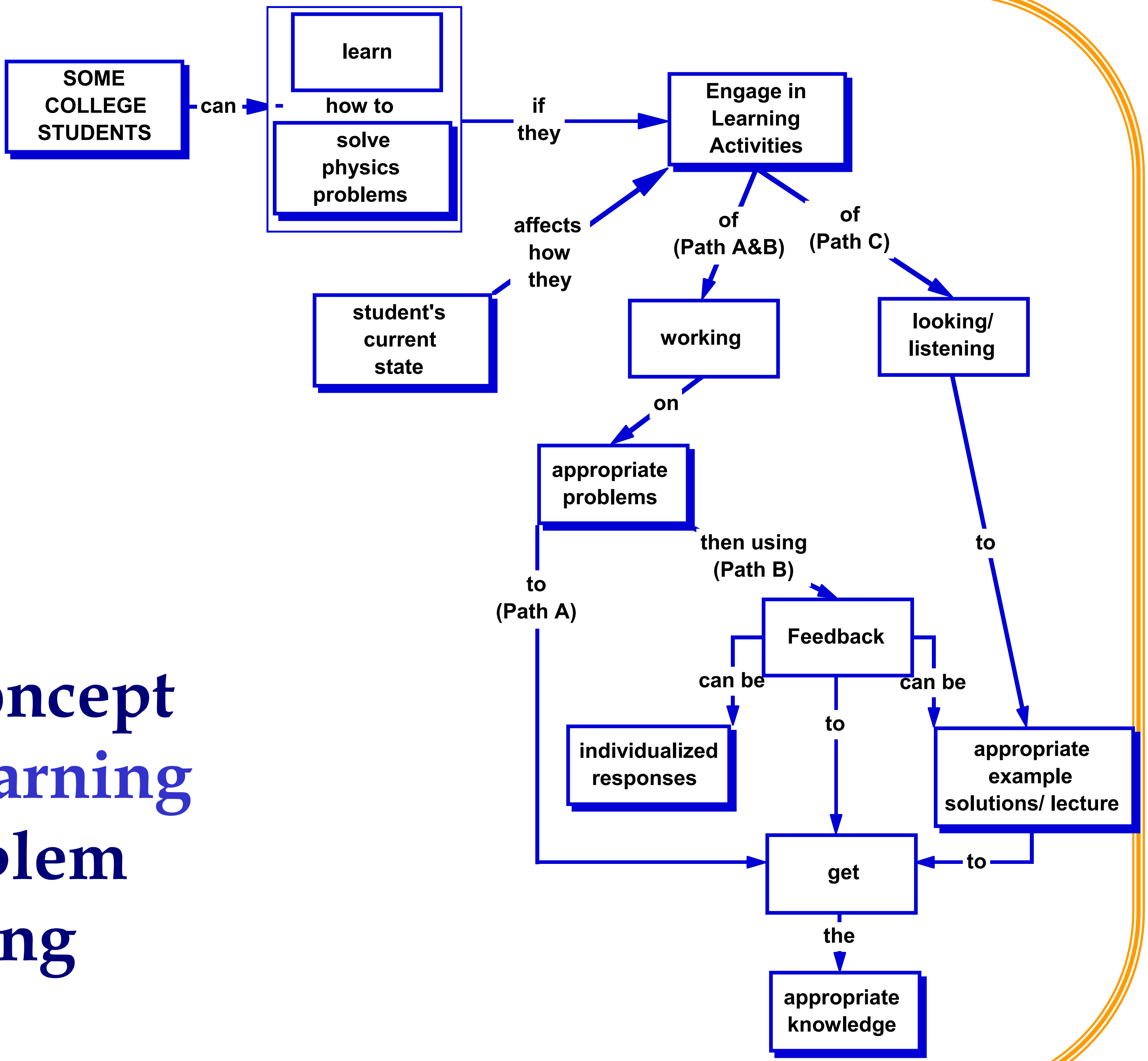
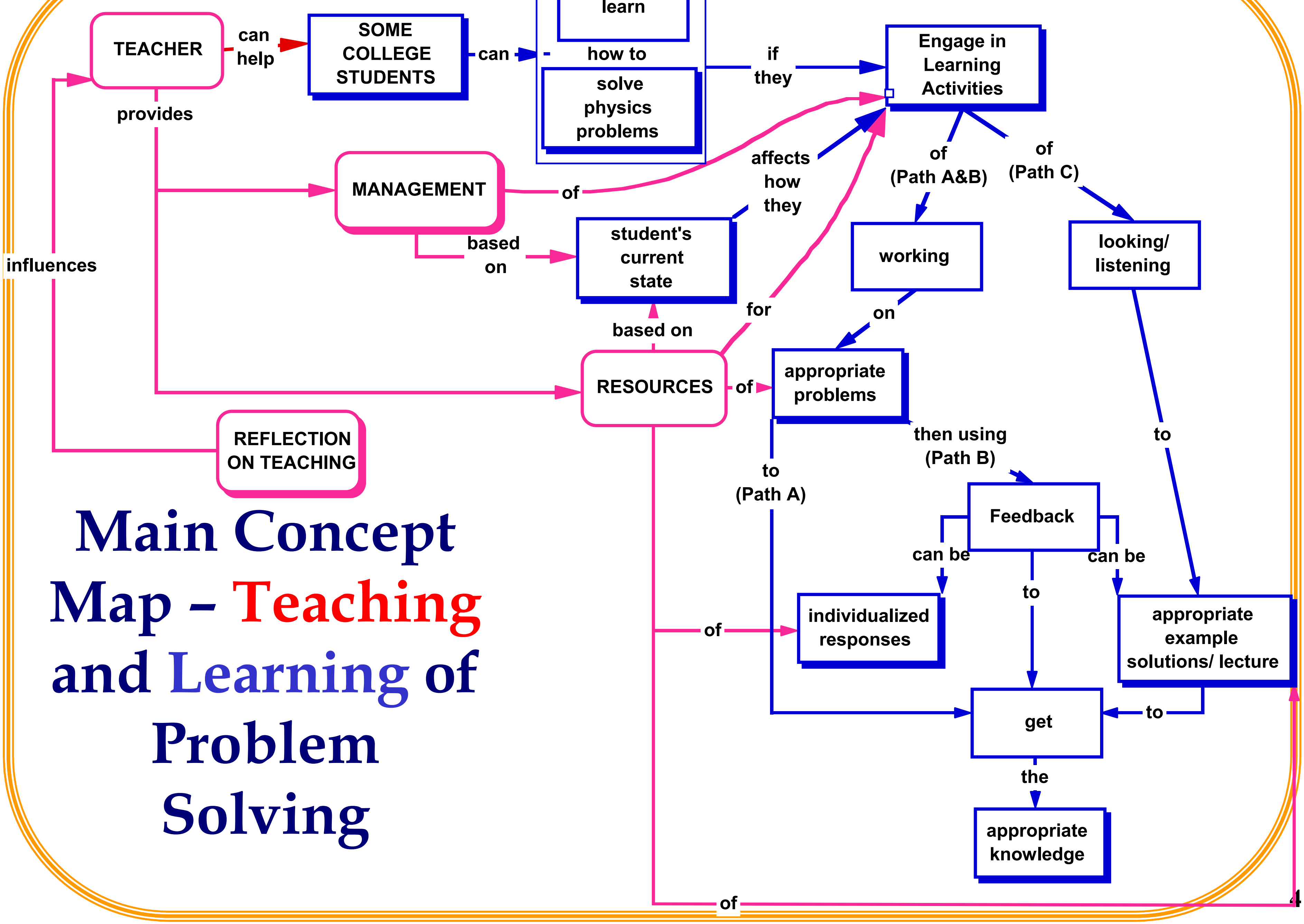
Outline

1. Introduce teaching concept map
2. Use the teaching concept map develop hypotheses about how physics instructors:
   - Decide what types of Example Problem Solutions use
   - View their role in managing student use of Example Problem Solutions
3. Develop hypotheses about what features of expertise physics instructors value in example problem solutions?

Main Concept Map – Learning of Problem Solving



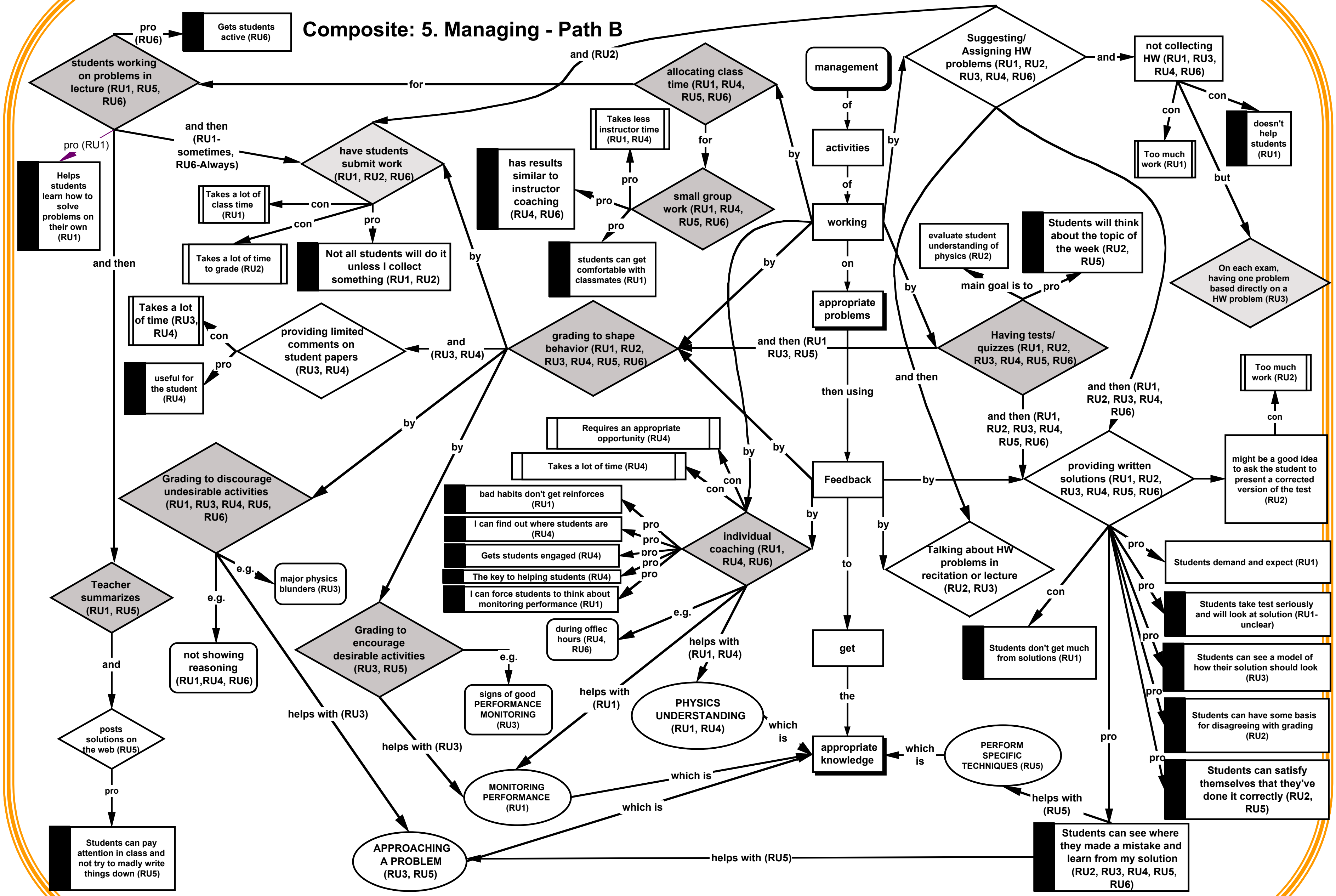
Main Concept Map – Teaching and Learning of Problem Solving



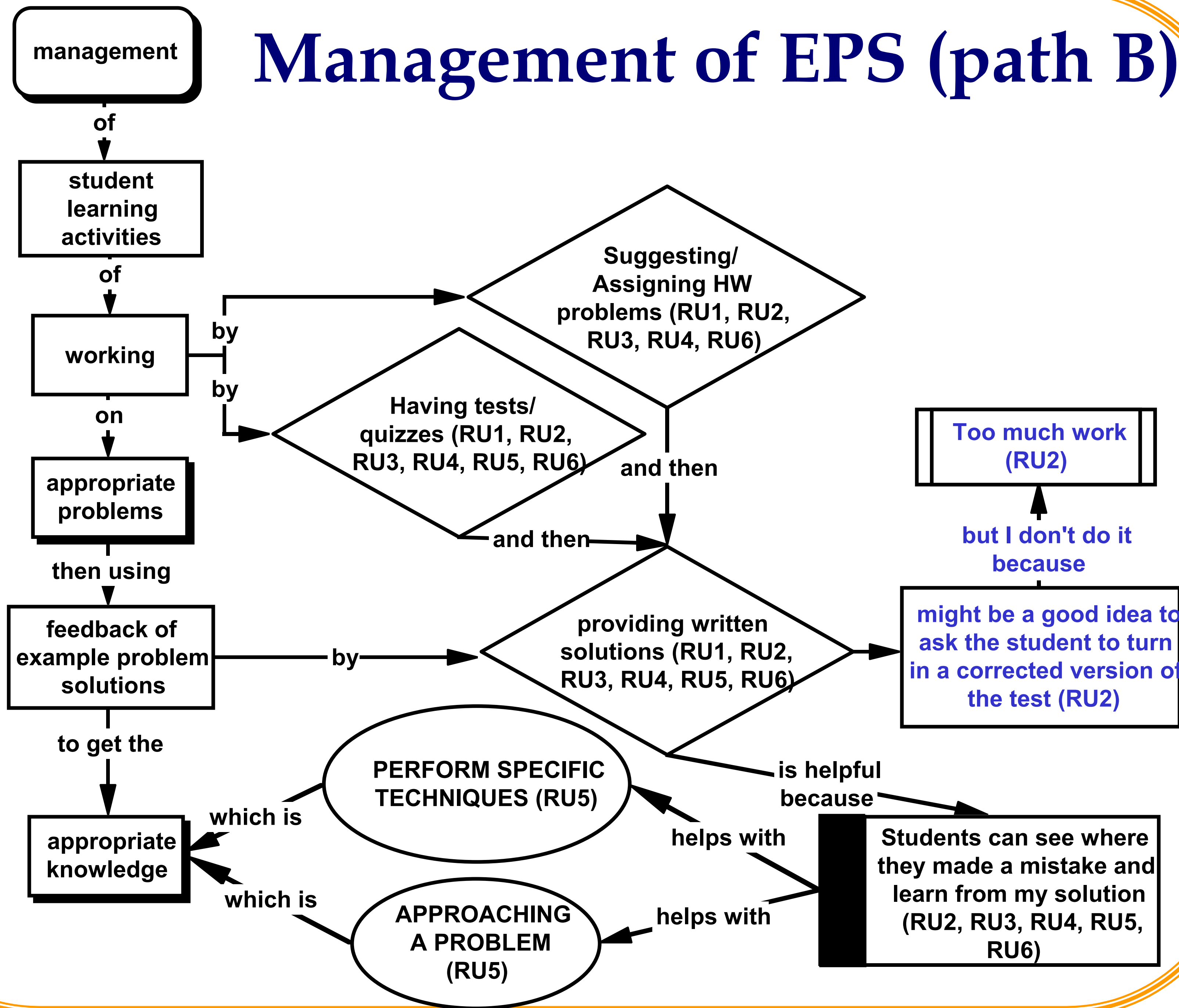
Management of Student Use of Example Problem Solutions (EPS)

- **All six instructors described their management of student use of EPS as:**
  - **Assigning test or homework problems for students to work on and then provide EPS** (path B – working and comparing)
  - **Working EPS on the board during lecture** (path C -- looking)

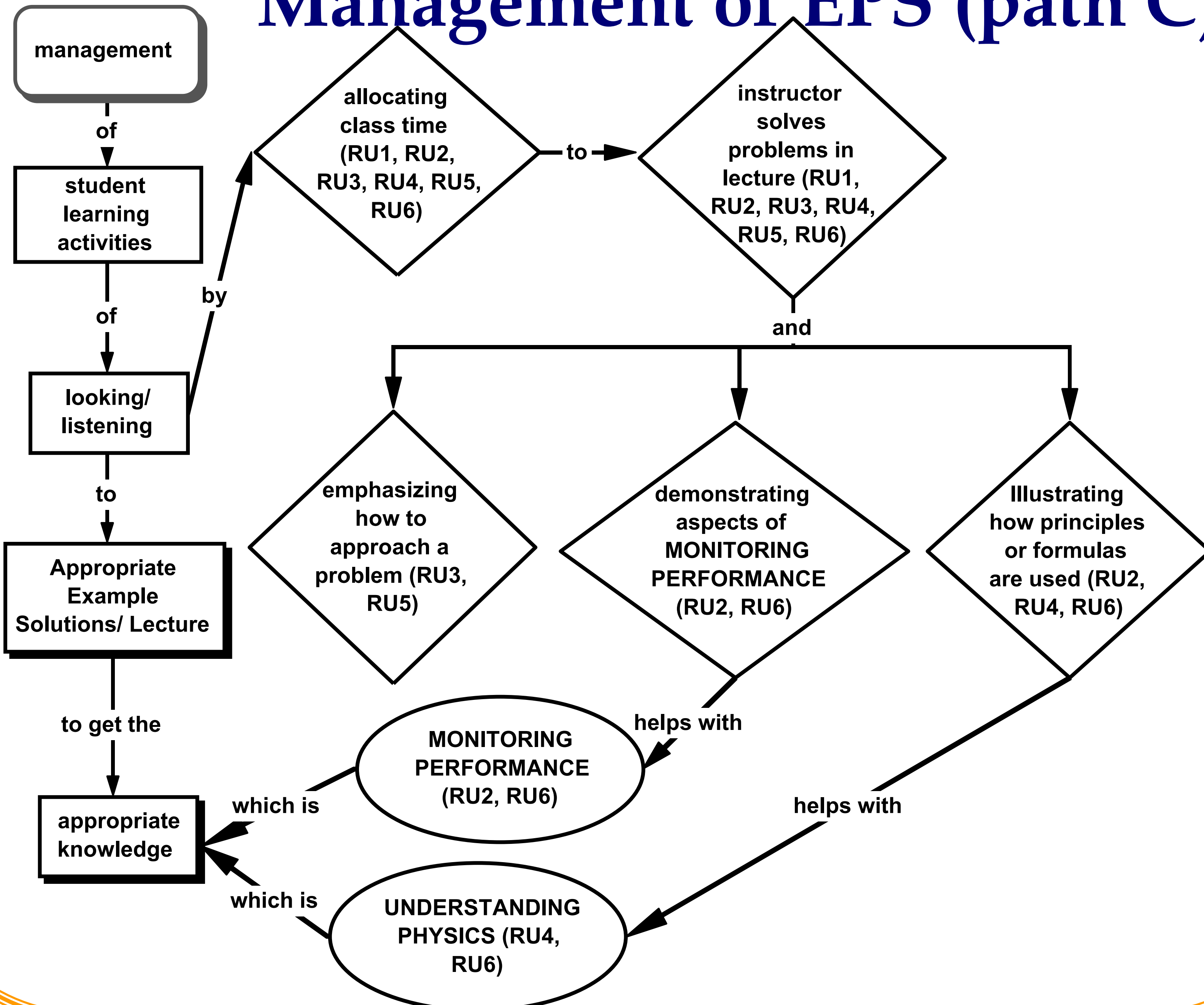
Composite: 5. Managing - Path B



Management of EPS (path B)



Management of EPS (path C)



Management of Student Use of Example Problem Solutions

- **All six instructors described their management as:**
  - **Assigning test or homework problems for students to work on and then provide written solutions**

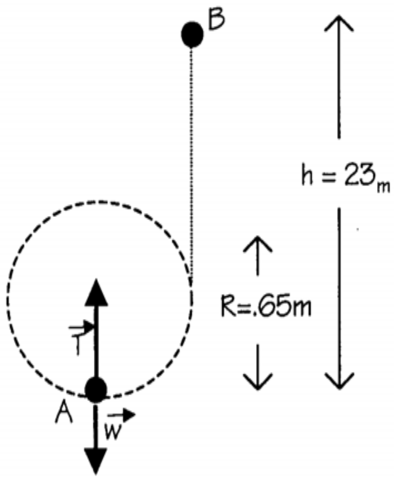
    (path B – working and comparing)
    - **Instructors think that students will learn by comparing these EPS to their test/HW solutions –**

      but, they don’t believe students do this
    - **Instructors don’t attempt to manage the situation further**
  - **Working example problems (that students have not previously seen) on the board during lecture**

    (path C – looking)
    - **Instructors don’t talk much about what students do in this situation or how this leads to learning**
    - **Instructors don’t attempt to manage the situation further**

Instructor solution I

"Bare-Bones Solution"



The tension does no work

Conservation of energy between point A and B

$$Mv_A^2/2 = mgh$$

$$V_A^2 = 2gh$$

At point A, Newton's 2nd Law gives us:

$$\vec{T} - \vec{w} = m\vec{a}$$

$$T - w = mv_A^2/R$$

$$T = 18_N + 2 \cdot 18_N \cdot 23_m / .65_m = \boxed{1292\text{N}}$$

"Emphasis on Details"

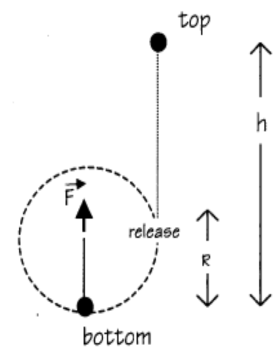
Each step explicitly written and goal clearly stated

Include clarifying comments

Instructor solution II

Known:
- $w = 18N$ = weight of stone
- $R = 0.65m$
- $h = 23m$
- $v_t = 0$ = velocity at top

Unknown:
- $v_r = ?$ = velocity at release
- $v_b = ?$ = velocity at bottom
- force my hand exerts = F=?



Step 1) Find v_r needed to reach h

$E_i = E_f$

$E_{release} = E_{top}$

$PE_{release} + KE_{release} = PE_{top} + KE_{top}$

$\cancel{m}gR + \cancel{m}v_r^2/2 = \cancel{m}gh + \cancel{m}v_t^2/2$ (with $v_t = 0$)

$v_r^2 = 2g(h - R)$

Conservation of energy for the stone earth system, since no external forces.

Note: you could also choose other systems.

KE of earth estimated to be 0

You could also use kinematics to find v_r.

Step 2) Find v_b needed to have v_r at release

$E_{bottom} = E_{release}$

$PE_{bottom} + KE_{bottom} = PE_{release} + KE_{release}$

$\cancel{m}g0 + \cancel{m}v_b^2/2 = \cancel{m}gR + \cancel{m}v_r^2/2$

Using v_r from above:

$V_b = [2gh]^{1/2}$

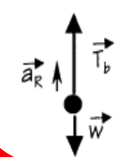
Conservation of energy for the stone earth system. Since $T \perp v$ in circular path, T does no work.

Step 3) Find T_b, tension at bottom, needed for stone to have v_b at bottom

$\sum \vec{F} = m\vec{a}$

$\sum F_R = ma_R$

$T_b - w = m\, v_b^2/R$



Free body diagram

To relate the forces to velocity we can look at the radial component, and use $a_R = v^2/R$.

Using v_b from above:

$T_b - w = 2\, mgh/R$

$T_b = w + 2\, w\, h/R = 18 + 2\ 18\ 23/.65 =$ **1292N**

T_b equals F, the force my hand exerts, for a massless string

"Emphasis on Reasoning"

Restating the question in physics terms

Planning the solution – including reasoning for each step

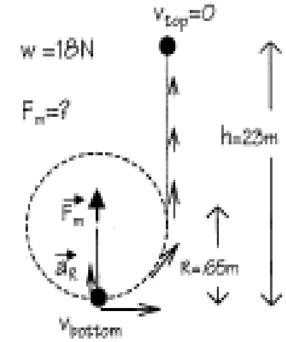
Starts from the target quantity (Tension)

Evaluation of final answer

Instructor solution III

Approach:

I need to find F_m, force exerted by me. I know the path, h (height at top) and v_t (velocity at top)



A) For a massless string $F_m = T_b$ (T_b-Tension at bottom)

B) I can relate T_b to v_b (velocity at bottom) using the radial component of $\sum \vec{F}=m\vec{a}$, and radial acceleration $a_R=v^2/R$, since stone is in circular path

C) I can relate v_b to v_t using either i) energy ii) Dynamics and kinematics

ii) Messy since forces/accelerations change through the circular path

i) I can apply work-energy theorm for stone. Path has 2 parts:

first - circular, earth and rope interact with stone,

second - vertical, earth interacts with stone

In both parts the only force that does work is weight, since in first part hand is not moving $\Rightarrow \vec{T}\perp\vec{v} \Rightarrow \vec{T}$ does no work.

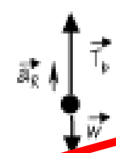
Execution:

B) Relate T_b to v_b

$\sum \vec{F}= m\vec{a}$

$\sum F_R= ma_R$

$T_b - w = m v_b^2/R$



C) Relate v_b to v_t

Work = ΔKE

For constant force

$\vec{F} \cdot \vec{d} = KE_f - KE_i$

$F_y d_y = KE_{top} - KE_{bottom}$

$-w\,h = m v_t^2/2 - m v_b^2/2$

0

Substituting C) into B)

$T_b - w = 2\,w\,h/R$

$F_m = T_b = w + 2\,w\,h/R$

$= 18 + 2\;18\;23/.65$

$=$ 1292N

N=N m/m units O.K.

Large compared to weight, but stone needs to travel up large distance

Check limits: $T_b\uparrow$ as $R\downarrow$, for smaller circle I'll need bigger force, reasonable

Providing Resources of Example Problem Solutions

- **All 6 instructors:**
  - **Distinguish between:**
    - **less detailed solution (IS1)**
    - **more detailed solutions (IS2, IS3)**
  - **Favored using solutions more detailed than IS1**
- **4 of the 6 instructors:**
  - **Said that their solutions were similar to IS1**

Factors Affecting an Instructor's Choice of EPS

	Less Detailed (IS1)	More Detailed (IS2, IS3)
How will it affect student learning?	• Students who were not able to do the problem might not be able to understand the solution (RU2)	• Makes it clear what is happening so students who had trouble can understand (RU1, RU2, RU3, RU4, RU5, RU6) • Can confuse students by discussing complications that some will not think of (RU3, RU4, RU6)
Will students use it?	• Makes the solution seem easier so students might read it (RU1, RU6)	• Can scare off students by having too many steps (RU1, RU2, RU3, RU6)
How hard is it to create?	• Easy to write or find in solution manual (RU2, RU4, RU5, RU6)	• I'm not good at spelling things out in detail like that (RU4)

What Types of Details do Instructors Prefer?

5 of the 6 instructors favored IS3 (over IS2)

IS2 (Emphasis on Details)	IS3 (Emphasis on Reasoning)
• Clear Steps (RU2) • Starts from known quantity (RU1) • Jumps right in with calculations (RU1) • Systematic approach implies that there is a standard way to do problems (RU4)	• Plans before execution (RU1, RU3, RU4) • Evaluates answer (RU3, RU6) • Explains reasoning (RU5, RU6) • Starts from target quantity (RU1)

Instructor Solution 3 Has Features of Expert Problem Solving

Features of Expert Problem Solving in IS3:	RU1	RU2	RU3	RU4	RU5	RU6
1. Restates problem in physics terms						
2. Starts from target (goal) quantity	✓					
3. Plans first then executes	✓		✓	✓	?	?
4. Evaluates answer			✓			✓

All features of expertise noticed were described as desirable

Preliminary Hypotheses

- Faculty do little to actively manage student use of problem solutions – they simply make the solutions available for students.
- Faculty consider three factors when deciding what types of solutions to use:
  - How will the solution affect student learning?
  - Will students use the solution?
  - How hard is it to create the solution?

Preliminary Hypotheses

- Faculty are dissatisfied with the solutions that they currently use.
- Implications: This is an opportunity for curriculum developers to influence the current practice by developing solutions that:
    - Make reasoning clear (especially by showing planning)
  - But are not
    - Too complicated → Confuse students
    - Too long → Scare students

Preliminary Hypotheses

- Faculty value features of expertise that they recognize in problem solutions.
- Faculty do not appear to recognize all features of expertise in problem solutions.
  - Many noticed planning before execution
  - None noticed restating the problem in physics terms
  - Some noticed:
    - starting from target quantity
    - evaluating answer
- Implications: Faculty may be unable to model features of expert problem solving in their problem solutions.

Next Steps

☑ Use 6 RU interviews to generate hypotheses

Use remaining 24 interviews to test/refine hypotheses

Use written questionnaire to expand to a larger national sample

Develop a map of instructors' values to guide curriculum developers

The End

For more information,
visit our web site at:

http://www.physics.umn.edu/groups/physed/

From Student Solutions Manual to Accompany Fundamentals of Physics, 5th ed. By Halliday, Resnick, and Walker. (Chapter 8)

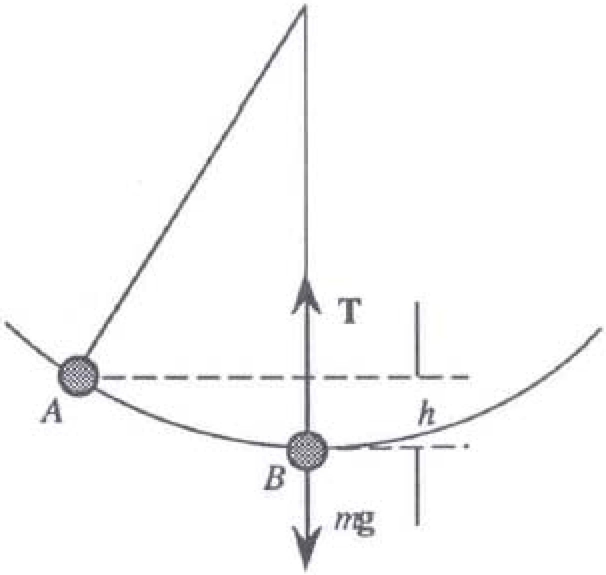
40P

Refer to the free-body diagram below. As Tarzan (of mass m) swings from point A to point B (the bottom of the swing), we have $\Delta K + \Delta U = 0$, i.e.,

$$\frac{1}{2}mv_B^2 - \frac{1}{2}mv_A^2 + mgh = 0\,,$$

which we solve for v_B:

$$v_B^2 = v_A^2 + 2gh = 2gh$$
$$= (2)(3.2\,\text{m})g = (6.4\,\text{m})g\,.$$



At point B, we may apply Newton's second law to Tarzan to obtain the equation for the tension T in the vine:

$$T - mg = \frac{mv_B^2}{R}\,,$$

which gives

$$T = mg + \frac{mv_B^2}{R} = mg + \frac{m(6.4\,\text{m}g)}{R} = (688\,\text{N})\left(1 + \frac{6.4\,\text{m}}{18\,\text{m}}\right) = 930\,\text{N}\,.$$

Since $T < 950\,\text{N}$, the vine will not break after all.

Providing Resources of EPS

- 5 of the 6 instructors favored IS3 (over IS2) based on the following features:
  - Plan first, then execute (RU1, RU3, RU4)
  - Explains reasoning (RU5, RU6)
  - Evaluates answer (RU3, RU6)
  - Starts from target quantity (RU1)