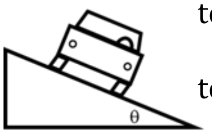
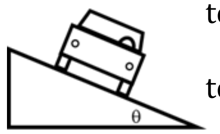
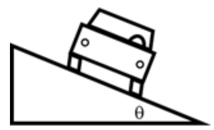
APPC, Mechanics: Unit β HW 2

Name: ______________________________
Hr: ___ Due at beg of hr on: ___________

Uβ, HW2, P1
Reference Video: "Physics of Banked Turns"
YouTube, lasseviren1, NEWTON'S LAWS OF MOTION playlist

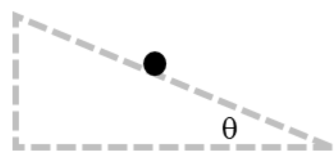
Below are three figures in which a car is going in a horizontal circle on a banked curve of slope θ. At each instant shown, the car is moving toward you (i.e., out of the page). The car has a mass *m*, the coefficient of static friction is μ_s, and the center of the circle is a distance *R* away, directly to your right.

A. Circle the correct answer, for each picture. "In this figure, the car is moving…"

	too fast too slowly at perfect speed		too fast too slowly at perfect speed		too fast too slowly at perfect speed

B. Inside the banked curves above, either (1) write "$F_s = 0$" <OR> (2) draw and label an arrow in the correct direction, to indicate EXACTLY which way the friction force F_s is pointing.

C. We will now consider ONLY the case of the car moving "at perfect speed." The dot in the figure represents the car. (I have included the banked curve so you can be sure to get your vectors pointed correctly. You're welcome. ☺)



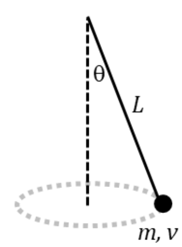
i. Draw a correct FBD for the situation described above. Use SOLID arrows for these vectors. Do NOT draw components, at this time.

ii. Above and to the right of the figure, sketch a coordinate-axis "legend" that applies here. HINT: It might be helpful to refer back to HW1, P1, Part Aiii to make sure you get this exactly right.

iii. One of your Part Ci vectors needs to be resolved for its components to lie along the axes of Part Cii. Resolve that vector now, in the figure, using DASHED arrows. Label the components meaningfully.

D. Here, write two equations: One with a trig function relating your Part Ciii components, and the other (easily) expressing one of those Part Ciii components in terms of other given variables.

E. Write a Newton's 2nd law equation. Then substitute your Part D answers into it and derive an expression for the "perfect" speed of the car on this banked curve.



Next, we deal with a battery-powered toy plane of mass *m* attached to a string of length *L*. The plane circles horizontally at a constant speed *v* and makes a constant angle θ with the vertical.

F. Down and to the right, draw an FBD of the plane. Use SOLID arrows.

G. Add to your FBD by resolving one of your Part F vectors. Use DASHED arrows and label the components meaningfully. HINT: HW1, P1, Part Aiii.

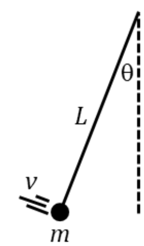
H. Repeat here what you did above in Part D.

I. Write a Newton's 2nd law equation, substitute your Part H answer into it and, finally, derive an expression for the speed *v* in terms of given quantities.

Uβ, HW2, P2
Reference Video: “Non-Uniform Circular Motion: Centripetal and Tangential Acceleration”
YouTube, lasseviren1

A. To review: Uniform circular motion (UCM) is circular motion at a ______________ speed. In such a case, the entire (or total) acceleration of the object is in the form of _______________________ acceleration, which conforms to the easy equation _________ and is always is directed…

B. In non-UCM, the object is turning AND, at the same time, its speed is either _____________________ or _____________________. There continues to be a _______________________ acceleration (or _____________ acceleration) and it is sometimes written as $\vec{a}_\perp$ because this acceleration is perpendicular to the _______________. The equation of this component – and its direction – is in accord with your Part A answer. However, for non-UCM, there is an additional acceleration component, called the _______________________ acceleration, symbolized _____, which is along the line of motion. Another symbol for this component is $\vec{a}_{//}$ because this acceleration is parallel to the _______________.



A pendulum has a mass m attached to a rope of length L. At the instant depicted, we also know the angle θ that the rope makes with the vertical and the mass’s speed v.

C. On the big dot, draw an FBD of the mass. Use SOLID arrows. Do NOT draw components.

D. Sketch a coordinate-axis “legend” that applies here. HINT: HW1, P1, Part Aiii.

E. Add to your FBD by resolving one of your Part C vectors, in accordance with your Part D answer. Use DASHED arrows, and label your new components.

This is one of the rare cases we will meet in which the acceleration in NEITHER direction equals zero (“Ahem…” This is the whole deal with non-UCM ☺).

F. In the space below, write TWO Newton’s 2nd law equations for this situation. Then derive expressions for (1) a_c, (2) a_t, and (3) the tension in the rope, in terms of the given quantities.

G. Whenever we know the two ⊥ components of any quantity, we can always find the magnitude of the overall (or total, or resultant) vector by using the _______________________ _______________.

H. Write out the expression a_{total} = ? that would result if you applied your Part G answer to two of your three Part F answers. DO NOT SIMPLIFY the expression; just show me what it looks like.

I. If we now wanted to find the mass’s speed at a later instant, we would want to use conservation of energy, and NOT Kinematics Equations I-IV. WHY? (HINT: What condition must be satisfied to use those equations, and how does that compare to what do you see in your Part H answer?)

Uβ, HW2, P3
Reference Video: “Physics of Elevators”
YouTube, lasseviren1, NEWTON’S LAWS OF MOTION playlist

A. Bathroom scales don’t tell us our weight; they tell us the ________________ force that is holding us up.

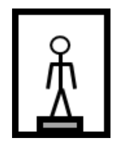
B. Suppose you have a scale in the bathroom right next to the sink. How will the scale read, compared to your actual weight, for each case? (CIRCLE)

i. you stand normally on the scale	EQUAL	MORE THAN	LESS THAN
ii. you stand while pushing downward on the sink	EQUAL	MORE THAN	LESS THAN
iii. during the time you’re jumping upward off the scale	EQUAL	MORE THAN	LESS THAN
iv. during the time you’re landing back down on the scale	EQUAL	MORE THAN	LESS THAN
v. you stand while lifting upward on the sink	EQUAL	MORE THAN	LESS THAN
vi. you stand on the scale with only one foot	EQUAL	MORE THAN	LESS THAN

C. Explain briefly how Newton’s 3rd law comes into play (and relates to your answers) in Parts Bii and Bv.

D. Explain how Newton’s 2nd law comes into play (and relates to your answers) in Parts Biii and Biv.

The figure shows an 80 kg person standing *on a scale in an elevator*. ☺ For the next few problems, (1) label FBDs using variables only, and (2) draw vectors to an appropriate length, i.e., the length should mean something. Also, for any calculations, use g = 10 m/s^2.



E. Suppose, at some point, the scale reads 800 N. Draw an FBD for this case.

F. For the case of Part E, determine the acceleration of the person/elevator.

G. List at least two possible things (depending how you word it, there could be three) that the elevator might be doing, for the case of Part E.

H. Suppose, at some point, the scale reads 680 N. Draw an FBD for this case.

I. For the case of Part H, determine the acceleration (mag. and dir.) of the person/elevator.

J. List the two possible, <u>specific</u> things that the elevator might be doing, for the case of Part H.

K. Suppose, at some point, the scale reads 1040 N. Draw an FBD for this case.

L. For the case of Part K, determine the acceleration (mag. and dir.) of the person/elevator.

M. List the two possible, <u>specific</u> things that the elevator might be doing, for the case of Part K.

Uβ, HW2, P4

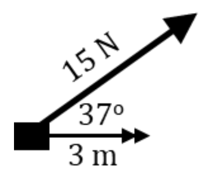
Reference Videos: (1) "The Scalar Product or Dot Product for Physics"
(2) "Dot Product"
YouTube, lasseviren1, WORK, ENERGY, AND POWER playlist

A. Why is it called the… i. …**scalar** product?

ii. …**dot** product?

B. Up until this point, we have had lots of practice **adding** vectors; now we will be ________________________ vectors. There are _______ different ways we can do this. We use the **dot product** (or **scalar product**) when we find we need to use two vectors that are oriented ____________________ to each other. We use the **cross product** (or **vector product**) when we need to use two vectors that are oriented _____________________________ to each other. (More on the cross product at a later time. ☺) One very important physical quantity that requires our use of the dot product is ________, and the two vectors (or vector components) that must be oriented ____________________ to each other to calculate this are ___________ and _____________________________. Again, when we use the dot product, our result is always a ________________ quantity; it will always have a ______________________ and will generally have a ________, but it will never have a __________________.

C. Find the work done by the force shown in the figure. You can see that the full force and the full displacement are NOT in quite the same direction. (Note also that the narrator uses $\vec{s}$ for displacement, but feel free to use whatever variable symbol makes you comfortable.) Do NOT use a calculator on this problem.



D. In general, for any two vectors $\vec{A}$ and $\vec{B}$, the magnitude of the dot product is found by using the equation…

E. Now, use a calculator to verify that your Part D answer, applied to Part C, does – in fact – give you the same answer as what you already showed in Part C. Show your work at right.

F. For taking the dot product of two vectors in unit-vector form, e.g., taking $\vec{A} \cdot \vec{B}$, where $\vec{A} = a_x\hat{\imath} + a_y\hat{\jmath}$ and $\vec{B} = b_x\hat{\imath} + b_y\hat{\jmath}$, we DO need to (here) "FOIL" our terms, just like we always do with polynomials. BUT…Why, then, is the net result merely $\vec{A} \cdot \vec{B} = a_x b_x + a_y b_y$? (i.e., Where did $a_x b_y$ and $a_y b_x$ go?)

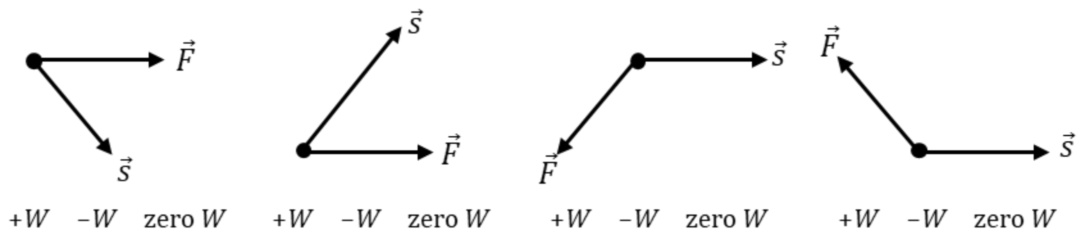
G. Determine the work done when a force $\vec{F} = 3\ N\ \hat{\imath} + 2\ N\ \hat{\jmath} + 1\ N\ \hat{k}$ acts over a displacement $\vec{s} = 2\ m\ \hat{\imath} + 7\ m\ \hat{\jmath} + 5\ m\ \hat{k}$.

Uβ, HW2, P5

Reference Video: "Work Done on an Object by a Constant Force"
YouTube, lasseviren1, WORK, ENERGY, AND POWER playlist

A. Write the equation from the video for finding the work done by a constant force $\vec{F}$ if the displacement is $\vec{s}$. HINTS: The equation should have TWO equals signs. Also, put vector symbols over vector quantities, and ONLY over vector quantities.

B. Circle the type of work for each case at right: (+) work, (–) work, or zero work.



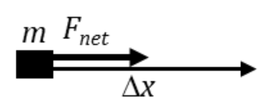
C. i. Zero work is done whenever…

ii. This is the case whenever the motion of the object is…

iii. Briefly explain how your answers to Parts Ci and Cii connect to your Part A answer. In your response, specifically mention the angle θ, i.e., what θ IS and how its presence in the equation connects to your two previous answers.

D. From the video, write the simplest equation for the **<u>work-energy theorem</u>**.

We will now derive a more specific and useful form of this theorem. Consider the figure at right, which shows a constant net force acting through a displacement.



E. Write the expression for the net work done W_{net} by the force. (This is very easy, since F_{net} and Δx are in exactly the same direction. ☺)

F. Write the Newton's 2nd law equation that applies here.

G. Substitute your Part F answer into your Part E answer.

H. Divide both sides of your Part G answer by the mass.

I. Write the kinematics equation sometimes called "The No-Time Equation." If you need to look this up, one place it can be found is on the assignment Uα, HW1, P3.

J. Substitute your Part H answer into your Part I answer.

K. Solve your Part J answer for W_{net}. (*Voila*! A useful work-energy theorem equation!)

L. Back in Part C, we were dealing with cases in which zero work is done. Your Part K answer shows that, in cases of zero work being done, the speed of the object will…