PHYS 1303
EXEMPLARY SOLUTIONS

Your solutions to practice and test problems should aim for the following format. This is intended to organize your thoughts in a clear and systematic way. This skill will help you to solve physics problems and also to explain your solution to a reader (who may be the PHYS 1303 grader, yourself 2 months later, or the Nobel Prize committee). If your final answer is wrong, you will receive partial credit in tests for following this format.

D I A N A

DESCRIPTION/ **D**IAGRAM – define symbols for unknowns sought and data given, label a diagram with your symbols, include a directed coordinate system, a few words to clarify perhaps.

IDEA – state the fundamental idea(s) or principle(s) of physics you will use. This can be expressed via an equation chosen from the formula sheet. You should then write out what it means for the current problem (symbolically).

ALGEBRA – symbolically derive the unknown you want

NUMBERS – substitute data for the knowns and perform calculation of the unknown

ANSWER – check number makes sense, round to appropriate precision, put units

Appended are exemplary solutions to a typical problem in each chapter of Halliday, Resnick and Walker. The red italics are commentary, so you can see how the solution is structured; you don't need to write it in your own solutions.

Test Grading Scheme Explanation

Each check mark is worth one point. The grader may sometimes mark an X or make a comment at the place you went wrong; this is for information only.
Check marks are embellished in 3 ways:
1.Diagram and/or Description (D) – see above
2.Method (M) - This is for *any valid* Method or step in the argument.
3.Answer (A) - This is for the correct final Answer, including units and appropriate precision.

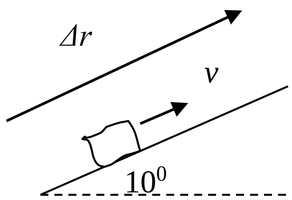
You will lose ½ point on an Answer (A) if either of the following occurred:

a) wrong units b) inappropriate precision (you cannot lose more than one ½ point due to precision on the test.)

Carry Through Error (CTE) - an incorrect Answer (A) or diagram (D) *may* be awarded the points if it resulted from the use of a previous erroneous result. The directly preceding method (M) points must have been awarded and the previous erroneous result should not have simplified the problem. CTE points are awarded at the discretion of the grader.

Chap 7 Problem. Boxes are transported from one location to another in a warehouse by means of a conveyor belt that moves with a constant speed of 0.50 m/s. At a certain location the conveyor belt moves for 2.0 m up an incline that makes an angle of 10° with the horizontal. Assume that a 2.0 kg box rides on the belt without slipping. At what rate is the conveyor belt doing work on the box?

Diagram/Description (1 point)



Box mass m = 2.0 kg
Box speed v = 0.50 m/s   constant
Box distance Δr = 2.0 m
Forces are static friction, normal, and gravity, all constant.
Friction and Normal are due to conveyor.

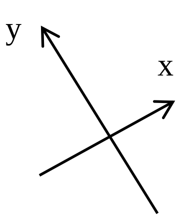
Idea (2 points)

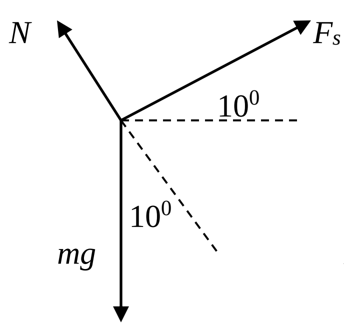
$W = \underline{\boldsymbol{F}} \bullet \underline{\boldsymbol{\Delta r}} = F\,\Delta r \cos\theta$

$P = W / \Delta t$

$v = \Delta r / \Delta t$ since constant velocity

Diagram/Description (1 point)





N = normal force magnitude (unknown)
F_s = static friction magnitude (unknown)
mg = gravity magnitude =2.0x9.8=19.6 N
$\underline{\boldsymbol{\Delta r}}$ in x direction

Idea (2 points)

Work done by N : $W = N\,\Delta r \cos 90^0 = 0$
Work done by F_s: $W = F_s\,\Delta r \cos 0^0 = F_s\,\Delta r$
$\Sigma F_x = ma_x = 0$ constant velocity
$+ F_s - mg \sin 10^0 = 0$

Algebra (no points)

$W = mg \sin 10^0 \, \Delta r$
$P = mg \sin 10^0 \, \Delta r / \Delta t$
$\quad = mg \sin 10^0 \; v$

Numbers (points given in Description for use of data)

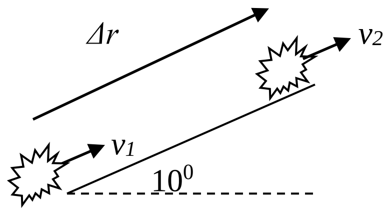
$= 19.6 \text{ x } \sin 10^0 \text{ x } 0.50$
$= 1.7017$

Answer (1 point)

$= \underline{\underline{1.7 \text{ W}}}$ (2sf)

Chap 8 Problem A volcanic ash flow is moving across horizontal ground when it encounters a 10° upslope. The front of the flow then travels 920 m up the slope before stopping. Assume that the gases entrapped in the flow lift the flow and thus make the frictional force from the ground negligible, and ignore air resistance. What was the initial speed of the front of the flow?

Diagram/Description (1 point)



Ash mass m (unknown)
Ash intial speed v_1 (required)
Ash final speed $v_2 = 0$
Ash distance $\Delta r = 920$ m

Idea (2 points)

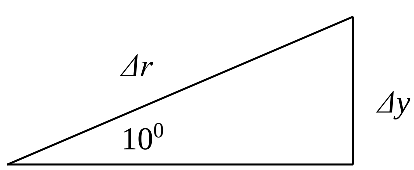
$\Delta E = \Delta K + \Delta U = 0$ mechanical energy conserved

$K_1 + U_1 = K_2 + U_2$

$\frac{1}{2} m\, v_1^2 + m\, g\, y_1 = \frac{1}{2} m\, v_2^2 + m\, g\, y_2$
$\frac{1}{2} m\, v_1^2 = + m\, g\, y_2 - m\, g\, y_1$

Diagram/Description (1 point)

$y_2 - y_1 = \Delta y$
$\Delta y / \Delta r = \sin 10^0$



Algebra (no points)

$\frac{1}{2} m\, v_1^2 = m\, g\, \Delta y$
$v_1^2 = 2\, g\, \Delta r \sin 10^0$
$v_1 = \sqrt{(2\, g\, \Delta r \sin 10^0)}$

Numbers (points given in Description for use of data)

$= \sqrt{(2 \times 9.8 \times 920 \sin 10^0)}$
$= 55.957$

Answer (1 point)
$=$ 56 m/s (2sf)

Chap 9 Problem. Two titanium spheres approach each other head-on with the same speed and collide elastically. After the collision, one of the spheres, whose mass is 300g, remains at rest. What is the mass of the other sphere?

Diagram/Description (1 point)

mass $m_1 = 0.300$ kg
mass m_2 required
initial speeds equal $v_{1i} = v_{2i}$
final speeds: $v_{1f} = 0$; v_{2f} unknown

$\longrightarrow$ + direction

Idea (2 points)

$\underline{\mathbf{p}}_{1i} + \underline{\mathbf{p}}_{2i} = \underline{\mathbf{p}}_{1f} + \underline{\mathbf{p}}_{2f}$ system linear momentum conserved

$+ m_1 v_{1i} - m_2 v_{1i} = + m_2 v_{2f}$

$K_{1i} + K_{2i} = K_{1f} + K_{2f}$ system kinetic energy conserved (elastic collision)

$\tfrac{1}{2} m_1 v_{1i}^2 + \tfrac{1}{2} m_2 v_{1i}^2 = \tfrac{1}{2} m_2 v_{2f}^2$

Algebra (1 point)

Substitute for v_{2f}

$$v_{2f} = (m_1 - m_2)\, v_{1i} \;/\; m_2$$

$$\tfrac{1}{2} v_{1i}^2 (m_1 + m_2) = \tfrac{1}{2} m_2 [(m_1 - m_2)\, v_{1i} \;/\; m_2]^2$$

$$(m_1 + m_2) = (m_1 - m_2)^2 / m_2$$ v_{1i} cancels, so value not needed.

$$m_2 m_1 + m_2^2 = m_1^2 - 2\, m_2 m_1 + m_2^2$$

$$0 = m_1 (\, m_1 - 3\, m_2)$$

$$m_1 = 3\, m_2$$ since $m_1 \neq 0$

Numbers (points given in Description for use of data)

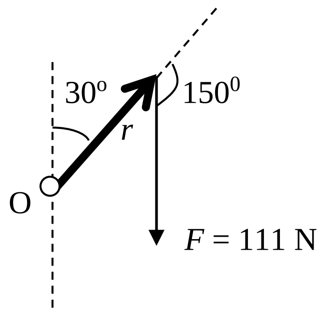
$m_2 = 0.300/3$
$= 0.100$

Answer (1 point)

= 100g (3sf)

Chap 10 Problem. The length of a bicycle pedal arm is 0.152 m and its mass is 0.35 kg. A downward force of 111 N is applied to the pedal by the rider. (a) What is the torque about the pedal arm's pivot when the arm is at angle 30° to the upward vertical? (b) What is the angular acceleration of the pedal arm at this time? (*assume the pedal arm is a thin uniform rod*)

Diagram/Description (2 points)



$\underline{\mathbf{F}}$ applied at $\underline{\mathbf{r}}$ produces a clockwise torque about O

r = 0.152 m
mass m = 0.35 kg

choose + direction clockwise

a)

Idea (1 point)

Torque magnitude
$\tau = rF \sin \phi$

Numbers (points given in Description for use of data)

τ = 0.152 x 111 x sin 150°
= 8.436

Answer (1 point)

$\underline{\tau}$ = $\underline{\underline{+ 8.4 \text{ Nm}}}$ (2sf)

The + sign together with the clockwise convention chosen above are necessary for indicating the torque vector. Alternatively, by the right hand rule, the vector direction may be specified as "into the page".

b)

Idea (1 point)

$\tau = I\, \alpha$

$\underline{\tau}$ and $\underline{\alpha}$ same direction (I scalar)

$I = mr^2 / 3$ Formula for rotational inertia of a rod about one end. (Formula would be given to you in a test question.)

Algebra (no points)

$\alpha = \tau / I = 3\,\tau / mr^2$

Numbers (points given in Description for use of data)

$\alpha = 3 \times 8.436 / (0.35 \times 0.152^2)$

$= 3129$

Use the <u>unrounded</u> value of τ calculated in part a), otherwise you make a rounding error on final answer.

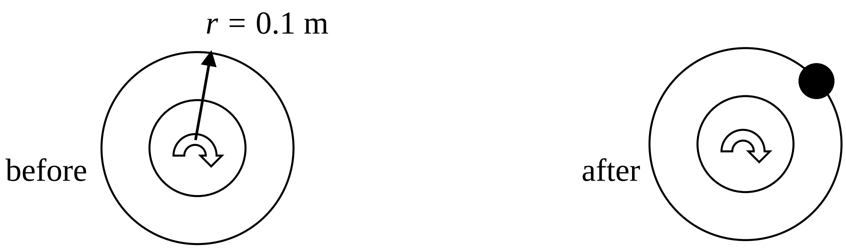
Answer (1 point)

$\underline{\boldsymbol{\alpha}} = \underline{+\,3.1 \times 10^3 \text{ rad/s}^2}$ (2sf)

The + sign together with the clockwise convention chosen above are necessary for indicating the angular acceleration vector. Alternatively, by the right hand rule, the vector direction may be specified as “into the page”.

Chap 11 Problem. A horizontal vinyl record of mass 0.10 kg and radius 0.10 m rotates freely about a vertical axis through its center with an angular speed of 4.7 rad/s and a rotational inertia of 5.0 x 10^{-4} kgm^2. Putty of mass 0.020 kg drops vertically onto the record from above and sticks to the edge of the record. What is the angular speed of the record immediately afterwards?

Diagram/Description (1 point)



Treat putty as point mass m = 0.1 kg at radius r

record angular speed ω_i = 4.7 rad/s
record rotational inertia I_i = 5.0 x 10^{-4} kgm^2

Record/putty angular speed ω_f (required)
Record/putty rotational inertia I_f (unknown)

Idea (2 points)

$I_i\, \omega_i = I_f\, \omega_f$

$I_f = I_i + mr^2$

Algebra (no points)

$\omega_f = I_i\, \omega_i / I_f = I_i\, \omega_i / (I_i + mr^2)$

Numbers (points given in Description for use of data)

= 5.0 x 10^{-4} x 4.7 / (5.0 x 10^{-4} + 0.1 x 0.1^2)
= 1.5666

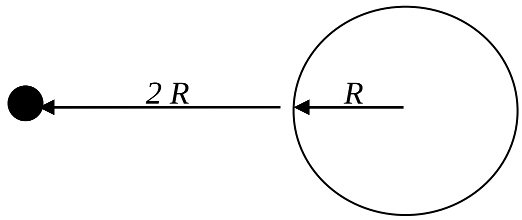
Answer (1 point)

= <u>1.6 rad/s</u> (2sf)

<u>Chap 13 Problem</u>. What is the magnitude of the free-fall acceleration at a point that is a distance $2R$ above the surface of the Earth, where R is the radius of the Earth and g = 9.80 m/s^2 at Earth's surface.

Diagram/Description (1 point)

Free-fall mass *m*



center to center distance = 3 R

Earth mass = M

Idea (2 points)

$G\,M\,m\,/\,(3R)^2 = m\,a$

$G\,M\,m\,/\,R^2 = m\,g$ mass *m* cancel out

Algebra (1 point)

Substitute for $GM\,/\,R^2 = g$
$a = GM\,/\,9R^2 = g\,/\,9$

Numbers (points given in Description for use of data)

$a = 9.80/9$
$= 1.0888$

Answer (1 point)

= <u>1.09 m/s^2</u> (3sf)