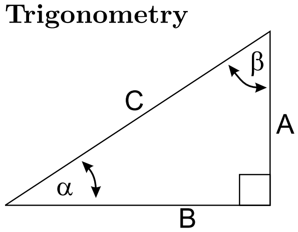
Scott Pratt

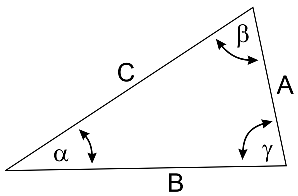
Do not open exam until instructed to do so.

Scott Pratt - PHY 231 - Introductory Physics I - Spring 2005 2
midterm3

Quadratic Formula
$ax^2 + bx + c = 0,$
$x = [-b \pm \sqrt{b^2 - 4ac}]/(2a)$
Geometry
Circle: circumference=$2\pi R$, area=πR^2
Sphere: area=$4\pi R^2$, volume=$4\pi R^3/3$
Trigonometry



$$\sin\alpha = \frac{A}{C}, \quad \cos\alpha = \frac{B}{C}$$
$$\tan\alpha = \frac{A}{B}$$



$$\frac{\sin\alpha}{A} = \frac{\sin\beta}{B} = \frac{\sin\gamma}{C}$$
$$A^2 + B^2 - 2AB\cos\gamma = C^2$$

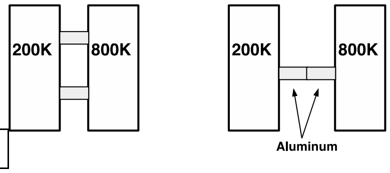
Polar Coordinates
$x = r\cos\theta, \quad y = r\sin\theta$
$r = \sqrt{x^2 + y^2}, \quad \tan\theta = y/x$
SI Units and Constants

quantity	unit	abbreviation
Mass m	kilograms	kg
Distance x	meters	m
Time t	seconds	s
Force F	Newtons	N=kg m/s^2
Energy E	Joules	J=N m
Power P	Watts	W=J/s
Temperature T	°C, °K or °F	$T_{\circ F} = 32 + (9/5)T_{\circ C}$
Pressure P	Pascals	Pa=N/m^2

1 cal=4.1868 J, 1 hp=745.7 W
$g = 9.81$ m/s^2, G=6.67×10^{-11} Nm^2/kg^2
0°C=273.15°K, $N_A = 6.023 \times 10^{23}$
$R = 8.31$ J/(mol°K), $k_B = R/N_A = 1.38 \times 10^{-23}$ J/°K
$\sigma = 5.67 \times 10^{-8}$ W/(m^{2}K^4)
$v_{\rm sound} = 331\sqrt{T/273}$ m/s
$H_2$0: $c_{\rm ice,liq.,steam}$=$\{0.5, 1.0, 0.48\}$ cal/g°C
$L_{F,V}$=$\{80, 540\}$ cal/g, $\rho = 1.0$ g/cm^3.

1-d motion, constant a
$x = (1/2)(v_0 + v_f)t$
$v_f = v_0 + at$
$x = v_0 t + (1/2)at^2$
$x = v_f t - (1/2)at^2$
$(1/2)v_f^2 - (1/2)v_0^2 = ax$
Momentum, Force and Impulse
$p = mv, \ F = ma = \Delta p/\Delta t$
$I = F\Delta t = \Delta p$
Friction: $F_{\rm fric} = \mu N$
Spring: $F = -kx$

Work, Energy and Power
$W = Fx\cos\theta, KE = (1/2)mv^2, \ P = \Delta E/\Delta t = Fv$
Spring: $PE = (1/2)kx^2$
Rotational Motion
$v = \omega r = 2\pi r/T, \quad \omega = \Delta\theta/\Delta t = 2\pi f = 2\pi/T, f = 1/T$
$\alpha = (\omega_f - \omega_0)/t = \frac{a}{r}$
$L = I\omega = mvr\sin\theta$, ($\theta$= angle between v and r)
$KE = (1/2)I\omega^2 = L^2/(2I)$
$\tau = rF\sin\theta, \ I\alpha = \tau, \ I_{\rm point} = mR^2$
$I_{\rm cyl.shell} = MR^2, \ I_{\rm sphere} = (2/5)MR^2$
$I_{\rm solid\ cyl.} = (1/2)MR^2, \ I_{\rm sph.\ shell} = (2/3)MR^2$
$a = v^2/r = \omega v = \omega^2 r$
Gravity and circular orbits
$PE = -G\frac{Mm}{r}, \ \Delta PE = mgh$(small h)
$$F = G\frac{Mm}{r^2}, \quad \frac{GM}{4\pi^2} = \frac{R^3}{T^2}$$
Gases, liquids and solids
$P = F/A, \ PV = NRT, \ \Delta P = \rho gh$
$\langle(1/2)mv^2\rangle = (3/2)k_B T$
$F_{\rm bouyant} = \rho_{\rm displaced\ liq.}V_{\rm displaced\ liq.}g$
Stress = F/A, Strain = $\Delta L/L$, Y = Stress/Strain
$\frac{\Delta L}{L} = \frac{F/A}{Y}, \frac{\Delta V}{V} = \frac{-\Delta P}{B}, Y = 3B$
Bernoulli: $P_a + \frac{1}{2}\rho_a v_a^2 + \rho_a g h_a = P_b + \frac{1}{2}\rho_b v_b^2 + \rho_b g h_b$
Heat
$\Delta L/L = \alpha\Delta T, \ \Delta V/V = 3\alpha\Delta T$
$Q = mC_v\Delta T + mL$(if phase trans.)
Conduction and Radiation
$P = kA(T_b - T_a)/\Delta x = A(T_b - T_a)/R,$
$R \equiv \Delta x/k, \ P = e\sigma AT^4$
Thermodynamics
$\Delta U = Q + W, \quad W = -P\Delta V$, ideal gas: $\Delta U = nC_V\Delta T$
Adiabatic exp: pV^γ =const, $TV^{\gamma-1}$ =const
$\gamma = C_p/C_V$=5/3 (monotonic), =7/5 (diatomic)
$Q = T\Delta S, \ \Delta S > 0$
Engines: $W = |Q_H| - |Q_L|$
$\epsilon = W/Q_H < (T_H - T_L)/T_H < 1$
Refrigerators and heat pumps: $W = |Q_H| - |Q_L|$
$\epsilon = Q_L/W < T_L/(T_H - T_L)$
Simple Harmonic Motion and Waves
$f = 1/T, \omega = 2\pi f$
$x(t) = A\cos(\omega t - \phi), \ v = -\omega A\sin(\omega t - \phi)$
$a = -\omega^2 A\cos(\omega t - \phi)$
Spring: $\omega = \sqrt{k/m}$
Pendulum: $T = 2\pi\sqrt{L/g}$
Waves: $y(x,t) = A\sin[2\pi(ft - x/\lambda + \delta)], \ v = f\lambda$
$I = {\rm const}A^2 f^2, \ I_2/I_1 = R_1^2/R_2^2$
Standing waves: $\lambda_n = 2L/n$
Strings: $v = \sqrt{T/\mu}$
Solid/Liquid: $v = \sqrt{B/\rho}$
Sound: $I = {\rm Power}/A = I_0 10^{\beta/10}, \ I_0 \equiv 10^{-12}$ W/m^2
Decibels: $\beta = 10\log_{10}(I/I_0)$
Beat freq.=$|f_1 - f_2|$
Doppler: $f_{\rm obs} = f_{\rm source}(V_{\rm sound} \pm v_{\rm obs})/(V_{\rm sound} \pm v_{\rm source})$
Pipes: same at both ends: $L = \lambda/2, \lambda, 3\lambda/2$
Pipes: open at only one end: $L = \lambda/4, 3\lambda/4, 5\lambda/4 \cdots$



2 pt A hot (800 °K) and a cold (200 °K) object are connected by two aluminum bars as shown.

▷ Compared to the configuration on the left, the rate of heat transferred in configuration shown the right is ________________ as high.

1. **A**◯ one fourth **B**◯ one half
C◯ one third

▷ Considering the left configuration only, lowering the temperature of the 800 °K block to 400 °K will reduce the rate of heat transfer by a factor of ________________________.

2. **A**◯ one fourth **B**◯ one half
C◯ one third

You are correct. Your receipt is 154-1432

4 pt A fixed number of moles of an ideal gas are kept in a container at a pressure P and temperature T.

▷ If P doubles while T is kept constant, the density of the gas will double.

3. **A**◯ True **B**◯ False

▷ If T quadruples, the r.m.s. velocity of the molecules in the gas will double.

4. **A**◯ True **B**◯ False

▷ If T doubles while P is held constant, the net internal energy of the gas will double.

5. **A**◯ True **B**◯ False

▷ If T doubles while P is held constant, the density must double.

6. **A**◯ True **B**◯ False

You are correct. Your receipt is 154-1749

4 pt Consider twins named Bert and Ernie who are visiting a planet named Izzone. Bert is standing at the top of the highest mountain on Izzone, a distance R from the center of the planet. Ernie flies by in a space ship which is in a stable circular orbit at the same altitude R.

▷ If Ernie were to step on a bathroom scale in his space ship, his weight would register as zero.

7. **A**◯ True **B**◯ False

▷ The same gravitational force acts on both Bert and Ernie, but Bert also experiences an additional force from the ground.

8. **A**◯ True **B**◯ False

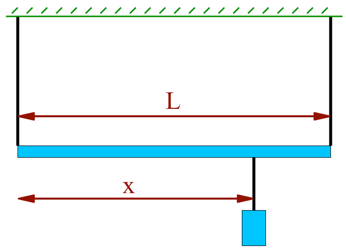
▷ Ernie and Bert undergo the same acceleration.

9. **A**◯ True **B**◯ False

▷ If Big Bird were to fly in a circular orbit of radius 3R, the gravitational force acting on Big Bird would be one third of the gravitational force acting on Ernie.

10. **A**◯ True **B**◯ False

You are correct. Your receipt is 154-1536

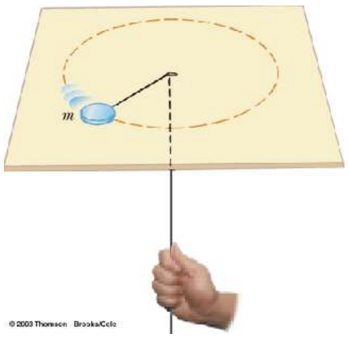


1 pt

Two wires support a beam of length L=12 as shown in the figure above. A box hangs from a wire which is connected a distance of 9 m from the left edge of the beam. The tension in the left support wire is 800 N and the tension in the right support wire is 1000 N. What is the mass of the beam? DATA: g=9.81 m/s^2 *(in* `kg`*)*

11.A◯ 142.7 **B**◯ 206.9 **C**◯ 300.1
D◯ 435.1 **E**◯ 630.9 **F**◯ 914.7
G◯ 1326.4 **H**◯ 1923.2

You are correct. Your receipt is 154-1641



1 pt ©2003 Thomson Brooks/Cole

The puck in the figure has a mass of 0.17 kg. Its original distance from the center of rotation is 50 cm, and the puck is moving with a speed of 1.1 m/s in a circle. The string is pulled downward until the center of rotation has moved to r=25 cm. The table is effectively frictionless. What is the work required to pull the puck to the new position? *(in* `J`*)*

12.A◯ 0.10 **B**◯ 0.13 **C**◯ 0.16 **D**◯ 0.20
E◯ 0.25 **F**◯ 0.31 **G**◯ 0.39 **H**◯ 0.48

1 pt One cubic meter of a building material weighs 6.5×10^4 N. If a column of the material collapses under its own weight if the column is taller than 1282 m, what is the compression strength (in Pa) of this material? (the maximum pressure that can be withstood by the material)

13.A◯ 6.09×10^7 **B**◯ 7.12×10^7 **C**◯ 8.33×10^7
D◯ 9.75×10^7 **E**◯ 1.14×10^8 **F**◯ 1.33×10^8
G◯ 1.56×10^8 **H**◯ 1.83×10^8

You are correct. Your receipt is 154-1641

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1 pt An immersion heater has a power rating of 1300 watts. It is used to heat water for coffee. How many minutes are required to heat 20.19 liters of water from room temperature (20°C) to 80°C?

14.A◯ 12 **B**◯ 16 **C**◯ 21 **D**◯ 28
E◯ 37 **F**◯ 49 **G**◯ 65 **H**◯ 86

You are correct. Your receipt is 154-1641

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1 pt A wooden statue of Elsie the cow is held under water in a swimming pool with a force of 5500 N. If Elsie's mass is 688.7 kg, what is the density of the statue? *(in* `kg/m^3`*)*

15.A◯ 144 **B**◯ 181 **C**◯ 226 **D**◯ 282
E◯ 353 **F**◯ 441 **G**◯ 551 **H**◯ 689

You are correct. Your receipt is 154-1655

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1 pt A gas contains NO_2 molecules at 18 °C. What is the r.m.s. speed of the molecules in m/s? The mass of a $N0_2$ molecule is $1.53 \cdot 10^{-26}$ kg.

16.A◯ 694.93 **B**◯ 785.28 **C**◯ 887.36
D◯ 1002.72 **E**◯ 1133.07 **F**◯ 1280.37
G◯ 1446.82 **H**◯ 1634.91

You are correct. Your receipt is 154-1524

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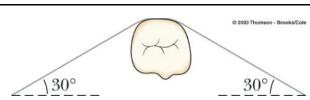
1 pt 

A stainless steel orthodontic wire is applied to a tooth, as shown in the figure above. The wire has an unstretched length of 25 mm and a cross sectional area of 3 mm^2. The wire is stretched 0.1 mm. Young's modulus for stainless steel is 1.8×10^{11} Pa. What is the tension in the wire? *(in* `N`*)*

17.A◯ 1325 **B**◯ 1497 **C**◯ 1692 **D**◯ 1912
E◯ 2160 **F**◯ 2441 **G**◯ 2758 **H**◯ 3117

You are correct. Your receipt is 154-1524

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1 pt A car is designed to get its energy from a rotating flywheel with a radius of 2.05 m and a mass of 525 kg. The flywheel is shaped like a pancake and can be considered as a uniform cylinder. Before a trip, the flywheel is attached to an electric motor, which brings the flywheel's rotational speed up to 4200 rev/min. If the flywheel is to supply energy to the car as would a 9500 Watt motor, find the time (in minutes) the car could run before the flywheel would have to be brought back up to speed.

18.A◯ 90 **B**◯ 102 **C**◯ 115 **D**◯ 130
E◯ 147 **F**◯ 166 **G**◯ 187 **H**◯ 212

You are correct. Your receipt is 154-1536

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1 pt A small Ferris wheel has a moment of inertia of 1.49E+6 kg*m^2 and is designed to rotate once every 10 seconds. Starting at rest, it undergoes an angular acceleration due to a motor that produces a torque of 1.50E+4 N*m. How many seconds will be required for the Ferris wheel to reach its designed rotational velocity?

19.A◯ 39 **B**◯ 46 **C**◯ 53 **D**◯ 62
E◯ 73 **F**◯ 85 **G**◯ 100 **H**◯ 117

You are correct. Your receipt is 154-1534

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1 pt A solid cylinder ($I = MR^2/2$) rolls down a hill of height 31 m without slipping. What is the velocity of the cyclinder at the bottom of the hill? DATA: g=9.80 m/s^2 *(in* `m/s`*)*

20.A◯ 10.7 **B**◯ 12.6 **C**◯ 14.7 **D**◯ 17.2
E◯ 20.1 **F**◯ 23.5 **G**◯ 27.6 **H**◯ 32.2

You are correct. Your receipt is 154-1532
