Physics 111 Spring 2019 Final Review

1. Budget your time: 150 minutes/28 questions=5.3 min each.
2. Use a calculator.
3. Answers are approximate. Select the closest one.
4. Use a #2 pencil on the Scantron card.

1. An airplane propeller starts to turn from rest and speeds up to 2 radians/s after turning 6 Radians. How long does it take, in s .

a. 6

b. 4

c. 3

d. 2

e. 1

Motion (no acceleration given)

$v = dx / dt$

$(v_o+v)/2 = x / t$

2. A tire on a car is turning initially at 500 radians/s. The car brakes and slows to a stop in 20 s. What is the acceleration in Radians/s^2?

a. -500

b. 0

c. 25

d. 700

e. -25

Acceleration

a = dv / dt

a = (v-vo)/t

3. A cylindrical, back-yard swimming pool has a weight of water of 80000N. The density of the water is 1000 kg/m^3 . What is the volume of the water in the pool in m^3 ?

a. 8

b. 80

c. 125

d. 1250

e. 40

Density and weight

$\rho = m/V$ and $F=mg$

4. A tablet of mass 0.3 kg is sitting on a table and exerting a pressure of 15 N/m^2.

What is the area of the tablet?

a. 0.02

b. 0.2

c. 1.5

d. 45

e. 600

Pressure and weight

$P = F/A$ and $F = m g$

5. Oil in a large pipe, area A1 = 10 m^2 , is flowing at a speed of 5 m/s. It then flows into a different part of the same pipe, area A2 = 2 m^2 . At what speed is the oil flowing, in m/s , in the second size region of the pipe?

a. 1

b. 50

c. 5

d. 25

e. 15

Flow

A V = Ao Vo

6. An astronaut with mass m= 70 kg, measures her weight to be 140 N on a space ship. What is the value of the effective gravitational field, g in N/kg, at that point?

a. 10

b. 3.5

c. 70

d. 0.5

e. 2.0

Weight

$F = m\,g$

7. A planet has a radius that is 1/3 the radius of the earth. The gravitational field on the surface of that planet is 4 times the gravitational field on the earth's surface. What is the ratio of the mass of the planet to the mass of the earth?

a. 2.5

b. 8

c. 1/2.5

d. 1.0

e. 4/9

Gravitational field

$g = G\,M/R^2$

$M = (4\,g_E)\,(R/3)^2 / G$

$= 4/9\ M_E$

8. You fly in a space ship from a point 16 Earth radii away from the center of the earth to a point where the earth's field is larger by a factor of 4. At how many earth's radii from the earth's center do you end up?

a. 4

b. ¼

c. 2

d. 8

e. ½

Gravitational field

$g = G\,M / R^2$

$(xR)^2 = G\,M / (4g)$

$(16R)^2 = G\,M / g$

$(x/16)^2 = 1/4$

$x = 8$

9. A drone slows in a straight line from a speed of 8 m/s with an acceleration of -2.5 m/s^2 . It takes 2 s . What is the final speed?

a. 10

b. 6

c. 2.8

d. 3

e. 4.5

Acceleration

a= dv/dt

a= (v-vo)/t

10. A truck starts from a speed of 100 m/s and accelerates at a = -20 m/s^2, in a straight, horizontal path for 5 s . How far does it go, in m ?

a. 250

b. 750

c. 0

d. 500

e. 50

Distance without v

$x = vo\ t + \frac{1}{2}\ a\ t^2$

11. A woman is pushing a lawn mower whose mass is 20kg across a horizontal yard. She pushes the mower with a force of 80 N that maintains a constant speed. What is the coefficient of friction?

a. 0.3
b. 0.4
c. 0.5
d. 0.7
e. 0.8

Friction and net force

$Ff = \mu N$ and $F - Ff = ma$

12. A lift has only 200 W of power in its battery. It tries to raise a box with a weight of 60 N for 30 s. How far, in m , can it lift the box?

a. Need to know the friction

b. 10

c. 25

d. 200

e. 100

Power and work

P= F / A and W = F . d

13. A rotating restaurant is moving a diner at constant speed in a horizontal circular path of radius R. The diner doesn't like the motion, so he moves to a seat where the acceleration is ½ and the linear speed is ½ the initial values. Where does he sit compared to his initial position at R?

- 1.25R
- R/4
- R/2
- R/8
- R

Rotation; constant v

a = v^2 /R

R=v^2 / a
xR=(v/2)^2 / (a/2)
x = (1/4) / (1/2)

14. A baby is dining in a rotating restaurant and has a moment of inertia of 100 kg m^2 . She is sitting at a radius R = 2 m from the center of rotation. What is the baby's mass in kg ?

25

12

100

4

18

Moment of inertia

I = c m R^2; for small object: c = 1

15. An auto mechanic turns a wrench with a torque of 300 N m. The wrench handle is 2 m long from the axis of rotation at a nut to the point where he applies his force at an angle of 30 degrees from the wrench handle. What is the magnitude of force, in N, that he applies?

a. 750

b. 150

c. 600

d. 300

e. 75

Torque

$T = |R|\ |F| \sin(\theta)$

16. A basketball player is spinning a huge, spherical shell (like a basketball) with a mass of 8 kg and a radius of 2 m. She applies a torque of

120 N m . What angular acceleration results, in Radians/s^2 ?

a. 7

b. 18

c. 1.2

d. 36

e. 5.6

Torque and moment of inertia

T = I α

and I = c m R^2 ; for spherical shell, c = 2/3

17. An engineer stops a train engine at the top of a hill. Then the engine starts down the hill with no power, no brakes and no friction. It goes over one hill and then over a second hill. The train is going 10 m/s at the top of the third hill and the engineer jumps out. What was the height difference between the first and third hills?

a. 10

b. 5

c. 6.3

d. 7

e. Can't tell without the height of the second hill

Conservation of energy: KE and PE

$\frac{1}{2} m v^2 = mgh$

18. An athlete pushes a heavy ball with a force with x, y and z components (3, 2, 1) N to move the ball for a vector displacement (10, 11, 12) m. What is the change in the sum of the kinetic and potential energy of the ball (neglecting friction) in J ?

a. 1.7

b. 3.4

c. 28

d. 64

e. 720

Conservation of energy and work (dot product)

KE + PE = W= d . F

19. A hollow sphere has a mass m = 4 kg and radius R = 0.7 m, A basketball player twirls it on his finger with a frequency of rotation of 1.2 revolutions/s. What is the value of the kinetic energy of rotation?

a. 1.7

b. 23.4

c. 0.91

d. 37.1

e. 53.5

Kinetic energy of rotation and moment of inertia and frequency

$KE = \frac{1}{2} I \omega^2$ and $I = c\, m\, R^2$ ($c=2/3$)

and $\omega = 2 \pi$ rps

20. A metal plate has a density 6000 kg/m^3 . The plate weighs 7.5 N in air and 5 N in a fluid, given that g= 10 N/kg, what is the density of the fluid in units of 1000 kg/m^3 ?

a. need the volume of the plate.

b. 1

c. 2

d. 3

e. 4

Boyancy

F=mg

$F= \rho V g$

$F-Fi = \rho_w V g$

21. The depth of a tank is 6 m. The density of the fluid in the tank is 500 kg/m^3 . How much less is the pressure at the top of a tank of fluid than the pressure at the bottom in units of 1000 Pascals?

a. 30

b. 50

c. 500

d. 5000

e. 300

Pressure

$P = F / A = \rho g h$

22. A force vector, **F** = (2, 1, 3) where the numbers are the (x, y, z) components in N. This force produces a torque by acting on the radius from the axis of rotation **R** = (1, 5, 4), in the same vector notation and in units of m. What is the resultant torque vector in units of N m ?

a. (4, 5, 6)

b. (2, 5, 12)

c. (-4, -5, 6)

d. (3, 6, 7)

e. (11, 5, -9)

Torque and cross product

T = R X F

	x	y	z	x	y
R	1	5	4	1	5
F	2	1	3	2	1

T

Constants: 1 inch = 2.54 cm; 1 mi =1.61 km; 1 cm=10^{-2}m; 1 mm= 10^{-3} m; 1 gram=10^{-3} kg;

$g = 9.8$ m/s^2 ; $G = 6.674\times10^{-11}$ N m^2/kg^2 ; $M_{Earth} = 5.97\times10^{24}$ kg ; $R_{Earth} = 6.37\times10^{6}$ m

1D and 2D motion: $x=x_i+(v+v_i)t/2$;

$x = x_i + v_i t + \frac{1}{2}at^2$; $v = v_i + at$; $v^2 = v_i^2 + 2a(x - x_i)$; $\vec{r} = \vec{r}_i + \vec{v}_i t + \frac{1}{2}\vec{a}t^2$; $\vec{v} = \vec{v}_i + \vec{a}t$

Circular motion: $T = 2\pi R / v$; $T = 2\pi / \omega$; $a_c = v^2 / R$

Force: $\sum \vec{F} = m\vec{a}$; $\vec{F}_{12} = -\vec{F}_{21}$; **Friction:** $f_s \le \mu_s N$; $f_k = \mu_k N$

Energies: $K = \frac{1}{2}mv^2$; $U_g = mgy$; $U_s = \frac{1}{2}kx^2$; $W = \int \vec{F}\cdot d\vec{r} = \vec{F}\cdot\Delta\vec{r}$

$E_{total} = K + U_g + U_S$ **;** $\Delta E_{mech} = \Delta K + \Delta U_g + \Delta U_s = -f_s d$ **;** $P = dW/dt = \vec{F}\cdot\vec{v}$ **;** $\Delta K = W$

Momentum and Impulse: $\vec{p} = m\vec{v}$; $\vec{I} = \int \vec{F}dt = \Delta\vec{p}$

Center of mass: $\vec{r}_{cm} = \sum_i m_i\vec{r}_i / \sum_i m_i$; $\vec{v}_{cm} = \sum_i m_i\vec{v}_i / \sum_i m_i$

Collisions: $\vec{p}$ = const and E≠ const (inelastic) or $\vec{p}$ = const and E= const (elastic)

Rotational motion: $\omega = 2\pi / T$ **;** $\omega = d\theta / dt$ **;** $\alpha = d\omega / dt$ **;** $v_t = r\omega$ **;** $a_t = r\alpha$

$a_c = a_r = v_t^2 / r = \omega^2 r$ **;** $a_{tot}^2 = a_r^2 + a_t^2$; $v_{cm} = r\omega$ (rolling, no slipping) ; $a_{cm} = r\alpha$

$\omega = \omega_o + \alpha t$; $\theta_f = \theta_i + \omega_o t + \alpha t^2 / 2$; $\omega_f^2 = \omega_i^2 + 2\alpha(\theta_f - \theta_i)$; $\theta - \theta_i = \frac{\omega_0+\omega}{2} t$

$I_{point} = MR^2$; $I_{hoop} = MR^2$; $I_{disk} = MR^2 / 2$; $I_{sphere} = 2MR^2 / 5$; $I_{shell} = 2MR^2 / 3$;

$I_{rod(center)} = \left\langle ML^2 / 12 \right\rangle$

$I_{rod(end)} = ML^2 / 3$; $I = \sum_i m_i r_i^2$; $I = I_{cm} + Mh^2$; $\vec{\tau} = \vec{r}\times\vec{F}$; $\sum \tau = I\alpha$; $\vec{L} = \vec{r}\times\vec{p}$; $\vec{L} = I\vec{\omega}$

Energy: $K_{rot} = I\omega^2 / 2$ **;** $K = K_{rot} + K_{cm}$ **;** $\Delta K + \Delta U = 0$ **;** $W = \tau\,\Delta\theta$ **;** $P_{inst} = \tau\omega$

Fluid: $\rho = \frac{M}{V}$ ***;*** $P = P_o + \rho g h$ ***;*** $A_1 v_1 = A_2 v_2$***;***

$P_1 + \rho g y_1 + \frac{1}{2}\rho(v_1)^2 = P_2 + \rho g y_2 + \frac{1}{2}\rho(v_2)^2$ ***;*** $B = \rho_{fluid} V^{object} g$

Gravitation: $\vec{F}_g = -\frac{Gm_1m_2}{r^2}\hat{r}_{12}$ **;** $g(r) = GM / r^2$ **;** $U = -Gm_1m_2 / r$; $T^2 = \frac{4\pi^2}{GM}a^3$

Math: 360° = 2π rad = 1 rev; Arc: $s = r\theta$; $V_{sphere} = 4\pi R^3 / 3$; $A_{sphere} = 4\pi R^2$; $A_{circle} = \pi R^2$

quadratic formula to solve $ax^2 + bx + c = 0$: $x = \frac{-b \pm \sqrt{b^2 - 4ac}}{2a}$

Vectors: $\vec{A} = A_x\hat{i} + A_y\hat{j}$; $A_x = \left|\vec{A}\right|\cos(\theta)$; $A_y = \left|\vec{A}\right|\sin(\theta)$; $\left|\vec{A}\right| = \sqrt{A_x{}^2 + A_y{}^2}$; $\tan\theta = \frac{A_y}{A_x}$

$\vec{C} = \vec{A} + \vec{B}$ => $C_x = A_x + B_x$; $C_y = A_y + B_y$;

Answers

1 a
2 e
3 a
4 b
5 d
6 e
7 3
8 d
9 d
10 a
11 b
12 e
13 c
14 a
15 d
16 e
17 b
18 d
19 d
20 c
21 a
22 e