Final Exam Review

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Physics 111

Exam Information

- Time: Dec 18, 2018 (Tuesday), 11:30 AM - 2:00 PM
- Location: Mechanical Engineering Center Building (ME; next to the GITC) Room 221
- Same format as before, but more questions (27 in total)
- You have about 5.6 minutes, on average, to work on each question

Exam Information: Topics

All materials in Weeks 1-14

- Roughly **half** of the questions come from those after Common Exam #3, i.e., topics in Weeks 11-14: Rotational Dynamics, Static Torque, Fluid Mechanics, Gravitation.
- Another **half** of the questions come from those already covered in Common Exams #1-3, i.e., topics in Weeks 1-10.

Final Exam Information: Review Sessions

- Thursday (Dec 13, Reading Day)

  11:30 am − 1:30 pm

  Tiernan Lecture Hall 1

  with Prof. Gordon Thomas
- Saturday (Dec 15)

  11:00 am − 1:00 pm

  Tiernan Lecture Hall 1

  with Society of Physics Students

FORMULAS – Final Exam

Conversion Factors: 1 inch = 2.54 cm; 1 mi =1609.3 m; 1 cm=10^{-2}m; 1 mm= 10^{-3} m; 1 gram=10^{-3} kg;

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

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

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

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

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

$\vec{A}\cdot\vec{B} = |\vec{A}||\vec{B}|\cos\theta = A_xB_x + A_yB_y + A_zB_z$; $\hat{\imath}\cdot\hat{\imath} = \hat{\jmath}\cdot\hat{\jmath} = \hat{k}\cdot\hat{k} = 1$; $\hat{\imath}\cdot\hat{\jmath} = \hat{\imath}\cdot\hat{k} = \hat{\jmath}\cdot\hat{k} = 0$

$|\vec{A}\times\vec{B}| = |\vec{A}||\vec{B}|\sin\theta$; $\vec{A}\times\vec{B} = \hat{\imath}(A_yB_z - A_zB_y) + \hat{\jmath}(A_zB_x - A_xB_z) + \hat{k}(A_xB_y - A_yB_x)$

$\hat{\imath}\times\hat{\imath} = \hat{\jmath}\times\hat{\jmath} = \hat{k}\times\hat{k} = 0$; $\hat{\imath}\times\hat{\jmath} = \hat{k}$; $\hat{\jmath}\times\hat{k} = \hat{\imath}$; $\hat{k}\times\hat{\imath} = \hat{\jmath}$

1D and 2D motion:

$v_{avg} = \dfrac{\Delta x}{\Delta t}$; $a_{avg} = \dfrac{\Delta v}{\Delta t}$; $v = \dfrac{dx}{dt}$; $a = \dfrac{dv}{dt} = \dfrac{d^2x}{dt^2}$

$\vec{v}_{avg} = \dfrac{\Delta\vec{r}}{\Delta t}$; $\vec{a}_{avg} = \dfrac{\Delta\vec{v}}{\Delta t}$; $\vec{v} = \dfrac{d\vec{x}}{dt}$; $\vec{a} = \dfrac{d\vec{v}}{dt} = \dfrac{d^2\vec{r}}{dt^2}$

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

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

Newtons Laws: $\sum\vec{F} = m\vec{a}$; $\vec{F}_{12} = -\vec{F}_{21}$

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) ; $a_{cm} = r\alpha$

$\omega = \omega_o + \alpha t$; $\theta_f = \theta_i + \omega_o t + \alpha t^2 / 2$; $\omega_f^2 = \omega_i^2 + 2\alpha(\theta_f - \theta_i)$

$I_{point} = MR^2$; $I_{hoop} = MR^2$; $I_{disk} = MR^2 / 2$; $I_{sphere} = 2MR^2 / 5$; $I_{shell} = 2MR^2 / 3$; $I_{rod(center)} = ML^2 / 12$

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

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: $\vec{F}_g = -\frac{Gm_1 m_2}{r^2}\hat{r}_{12}$; $g(r) = GM / r^2$; $U = -Gm_1 m_2 / r$; $T^2 = \frac{4\pi^2}{GM} a^3$

Fluid

Cubic water balloon

26. A liquid has a density of 150 kg/m3. It fills a cubic tank that measures 0.1m in each side. How much does it weigh, in N?

a. 0.15

b. 1.5

c. 15

d. 150

e. 1500

Density=m/V
W=mg
W=density*V*g
=1.5

Drowning a Balloon

27. A scientist has a balloon that weighs 0.001kg. She immerses it in water by pushing down with 15 N. The density of water is 1000 kg m^{-3}. How big is the balloon, in $(1/1000)m^3$?

a. 1.5

b. 0.65

c. 6.5

d. 0.15

e. Can’t tell.

Water Pressure in the Home

- Water enters a house through a pipe with an inside diameter of 2.0 cm at an pressure of 4×10^5 Pa. A 2.0-cm-diameter pipe leads to the 2nd floor bathroom 5 m above. When the flow speed at the inlet pipe is 1.5 m/s, Find the pressure on the second floor in 10^5 pa.

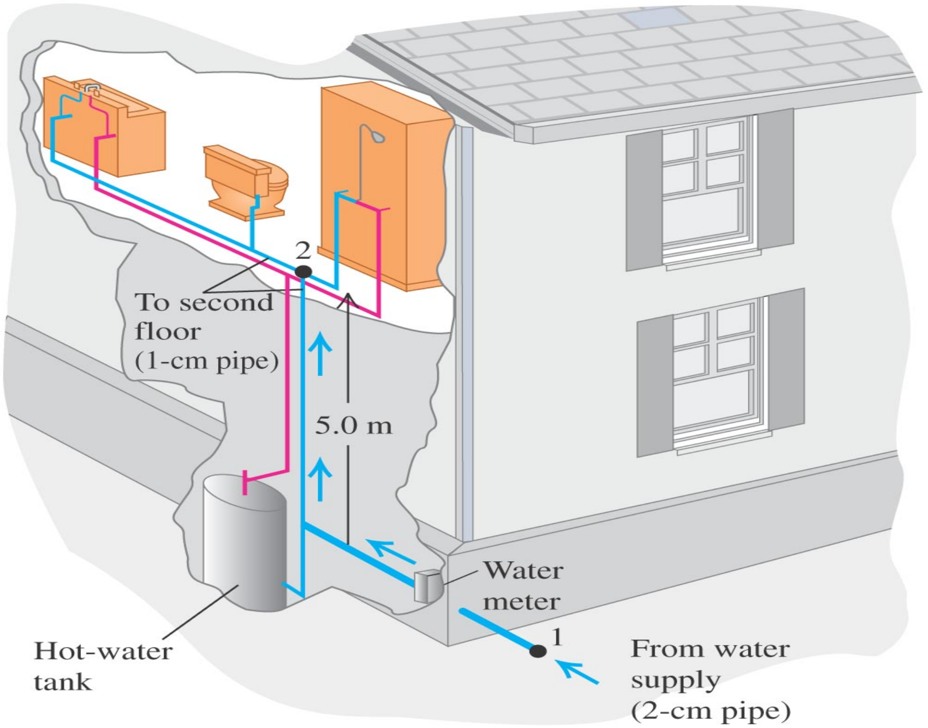
  A) 3

  B) 1

  C) 4.5

  D) 4

  E) 3.5



$$p_1 + \rho g y_1 + \frac{1}{2}\rho v_1^2 = p_2 + \rho g y_2 + \frac{1}{2}\rho v_2^2$$

$$v_2 = \frac{A_1}{A_2} v_1 = 1.5 \text{ m/s}$$

$$p_2 = p_1 - \frac{1}{2}\rho(v_2^2 - v_1^2) - \rho g(y_2 - y_1) = 3.5\times10^5 \text{Pa}$$

Gravity

Gravitation field

A planet has a gravitational field of 15.7 N/kg on its surface. While descending on to the planet, an astronaut measures a gravitational field of 0.63 N/kg. What is the distance of the astronaut above the planet's surface, in terms of the planet's radius?

a. 2
b. 25
c. 16
d. 4
e. 5

$g=GM/R^2$

Elevator on another planet

25. An empty elevator, M=100kg, has a counter weight m=90kg connected by a cable over a pulley with coefficient of friction 0.05. The elevator falls 20m and lands with a velocity of 1m/s. The accident happens not on earth but on a different planet. What is g in N/kg ?

- a. 48
- b. 24
- c. 9.5
- d. 4.3
- e. 2.1

F.d=(M+m)vv/2= 95
F=(M-m)g –mu (M+m)g
g=F/[M-m-mu(M+m)]=F/[0.5]
g=(95/20)/.5=9.5

Astronaut in Orbit

- I weigh 600 N on the surface of the earth. If I travel on a space shuttle orbiting at a distance of 3 times the Earth's radius above ground. What is my mass in kg at the space shuttle?

a. 3.83   b. 6.80   c. 15.3   d. 3.83   e. 61.2

Mass is an intrinsic measure of the object, and does not change with distance!

More Practice Problems

Testing a weapon

14. A 0.007kg bullet is fired into a stationary block with mass 3.5 kg, on a frictionless, horizontal surface. After the collision, the bullet gets stuck in the block and they move together at 1 m/s. Find the initial speed of the bullet in m/s.

a. 500

b. 200

c. 150

d. 125

e. 10

mV= (M+m)v
V=v(M/m) approx.
V=500

Rock climber hangs on

18. A rock climber on a ledge pushes a block of mass m = 2.1 kg up against a vertical wall at an angle of 40 degrees. The coefficient of static friction between the block and the wall is 0.5. What is the minimum force, in N, needed to keep the block from sliding down?

a. 15

b. 41

c. 25

d. 19

e. 0

F up =F down
F up= F cos40+ m*F sin 40
F down =mg
F=mg/(cos40+m*sin40)=19

Walking in a Wind storm

22. A strong wind is blowing South with a force of 15 N. A woman moves 4m east and then 3m North. How much work is done by the wind during her walk?

a. +45 J

b. -45 J

c. +60 J

d. -75 J

e. +15 J

W=**F.d**
F=-15
d= 3   opposite
W=-45

Rotating disk

- A student drops a ring on a rotating disk with an angular speed of 10 radians/s. The disk has moment of inertia of 4.0 kg m^2. After the drop, the disk and ring are rotating together with an angular speed of 5 kg m^2 radians/s. What is the momentum of inertia of the ring?
- A. 4
- B. 2
- C. 1
- D. 5
- E. 16

In the figure, point *P* is at rest when it is on the *x*-axis. The linear speed of point *P* when it reaches the *y*-axis is closest to

- A) 0.18 m/s.
- B) 0.24 m/s.
- C) 0.35 m/s.
- D) 0.49 m/s.
- E) 0.71 m/s.